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Business Model Innovations: Analyzing Business Model Patterns and Transformation Paths

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Preface

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Abstract

Problem Statement: Firms increasingly compete on business models. In particular digital business models have become more important and successful than their underlying products, processes, or services. To fully leverage the advancements of digital technologies, firms need to continuously innovate and reinvent their business models. The development of competition based on business models additionally requires firms to continually innovate their business models. Hence, business model innovation is a central capability for long-term profitability and growth. Firms need to understand and know how to do so. However, many business model innovations fail. The majority of firms use experimentation and trial-and-error learning for business model innovations without systematic guidance or structure. Business model patterns can support business model innovations. Since 90% of business model innovations nowadays are combinations of existing patterns, patterns can be used to learn from analogies and similar cases. They further help to think out-of-the-box and stimulate creativity and inspiration. However, the extant literature on business model patterns is chaotic and does not show their potential. The literature on emerging digital business model patterns is limited and research lacks an understanding of how firms conduct business model innovations.

Research Design: To fill this gap, we review the literature and structure identified business model patterns with a taxonomy as a basis for our mixed-method approach. We then quantitatively analyze the impact of business model patterns on firm performance. Further, we search for emerging digital business model patterns with case studies, case surveys, and taxonomy development including quantitative methods. Moreover, we investigate transformation paths and processes of business model innovations with case studies. All in all, we analyzed 648 cases in this thesis.

Results: We first developed a hierarchical taxonomy of business model patterns to structure extant literature. Second, we promote their potential by revealing patterns that significantly perform better than others. Third, we detected emerging digital business model taxonomies and patterns for Industry 4.0 and blockchain technology. Fourth, we found transformation paths for business model innovations in the context of servitization. Fifth, we developed a practical process framework for conducting business model innovation with the help of external stakeholders. Thus, results cover various supporting facets of business model innovation.

Contributions: The results of this thesis mainly contribute to strategy and information systems literature. The business model taxonomies, patterns, transformation paths, and innovation processes of this thesis add to our understanding of business models and its formalization and conceptualization as a theoretic construct. Further, we contribute by showing how advancements in information technology (IT) shape new business models, transformation paths, and innovation processes. Practical implications include guidelines in the form of business model patterns, transformation paths, and innovation processes.

Limitations: This research is subject to different limitations. Although we followed a mixed-method approach, qualitative methods dominate. On the one hand, the qualitative methods, in particular, case studies based on interviews, come with limited generalizability. To mitigate this limitation, we added case surveys. Interviews can further include a researchers' bias, which we

countered with data triangulation and several interview partners. On the other hand, the quantitative studies and case surveys are limited to the given information on cases and rely on the researchers' coding. Again, we included as much data as possible to build on rich information for case coding and ensure data triangulation.

Future Research: This thesis provides initial steps towards five aspects for future research. First, future research can build on our conceptualizations of business models to reach a wide-ranging establishment of the business model as a profound theoretical construct for research. Second, as advancements in IT move forward and will enable new business models, future research can extend our initial business model pattern language. Third, future research can build on our collection of taxonomies and patterns to develop a maturity model for digital business models. Patterns can be used as stages of digital maturity. Fourth, future research can use our results on business model innovation processes and open innovation to further investigate the role of information systems for new forms of processes. Fifth, research can extend our broad quantitative analysis of business models and firm performance with profound econometric analyses with incumbent firms differentiating between industries and other contexts. Hence, this thesis is just the first step towards fruitful research on business models and its innovation.

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List of Abbreviations

AMCIS	Americas Conference on Information Systems
API	Application Programming Interface
APJIS	Asia Pacific Journal of Information Systems
CON	Conference
ECIS	European Conference on Information Systems
EFI	Expertenkommission Forschung und Innovation
EM	Electronic Markets
IoT	Internet of Things
IJPE	International Journal of Production Economics
IT	Information Technology
JNL	Journal
NR	Not Ranked
P	Publication
PACIS	Pacific Asia Conference on Information Systems
RQ	Research Question
VHB	Verband der Hochschullehrer für Betriebswirtschaft/ German Academic Association for Business Research
WI	Internationale Tagung Wirtschaftsinformatik

Part A

1 Introduction

1.1 Motivation

Business models are increasingly important for competitive advantage (Zott et al. 2011; Massa et al. 2017). Firms more and more compete on business models instead of products or processes (Gassmann et al. 2013). In the past, manufacturing tangible high-quality products has been the most important aspect of competitive advantage (Vargo/Lusch 2008). Offering the best product at a competitive price led to market leadership. Firms focused on tangible outputs.

However, nowadays business model innovations and overcoming prevailing industry logics enable firms to rapidly become enormous successful (Gassmann et al. 2016). A focus on new products is not sufficient anymore for long-term competitive advantage (Gassmann et al. 2013). There are several examples where firms entered a market, offered similar products or services with a different business model, and quickly gained success. Airbnb, for example, is now the leading platform for private temporary accommodations and started without own hotel rooms (Hein et al. 2020). Similarly, Uber started as a platform for ride-hailing with private drivers and transformed the taxi market worldwide without own cars (Hein et al. 2020). There are additional examples beyond platform business models. Nespresso, for instance, offers a coffee maker for capsules at a very low price and sells needed consumables, i.e., coffee capsules, five times as expensive as regular coffee (Gassmann et al. 2013). Another example is Xerox. They introduced a usage-based leasing contract instead of selling their model 914, which enabled the firm to become very lucrative (Chesbrough/Rosenbloom 2002). Several additional examples and research confirm that firms increasingly compete on business models (Zott et al. 2011; Lambert/Davidson 2013; Foss/Saebi 2017; Massa et al. 2017). We understand business models as “the design or architecture of the value creation, delivery, and capture mechanisms [a firm] employs” (Teece 2010) and “how the enterprise creates and delivers value to customers, and then converts payments received to profits” (Teece 2010).

Advancements in information technology (IT) further increase the importance of business models for competitive advantage (Chesbrough 2010). New technologies change whole economies by enabling new business models. There are several examples, such as multi-sided markets based on digital platforms: eBay, Amazon, Netflix, Apple iTunes, Apple Music, Apple App Store, Google Play Store, AirBnB, Uber, Tinder, or WeChat (Parker et al. 2016; Gassmann et al. 2013; Gassmann et al. 2016; Afuah 2014). Other examples show different digital business models, such as offering services for free, as Google did with its search engine, which became a standard (Afuah 2014). An example of a freemium digital business model is Skype. It became the largest telecommunication provider without a network infrastructure by building on the VoIP technology (Gassmann et al. 2013; Gassmann et al. 2016). There are several other examples of prospering digital business models (Remané et al. 2017a).

As firms compete on business models and especially digital business models show tremendous success, incumbent as well as young firms need to be able to innovate and continuously reinvent their business models. Firms can build on business model innovations to leverage new digital technologies, remain competitive, and establish long-term profitability and growth (Chesbrough 2010). We see business model innovations as “designed, novel, nontrivial changes to the key elements of a firm's business model and/or the architecture linking these elements" (Foss/Saebi 2017).

However, many business model innovations fail (Christensen et al. 2016). Firms have problems with innovating their business model and leveraging advances in IT (Christensen et al. 2016). The reasons are multifaceted. Cultural values and processes of a firm can support product innovation but impede business model innovation (von den Eichen et al. 2015). Especially incumbents in traditional industries might not have sufficient digital capabilities and resources for conducting business model innovation. One practical solution is to build on experimentation and trial-and-error learning (McGrath 2010; Chesbrough/Rosenbloom 2002; Sosna et al. 2010). However, these methods do not provide systematic guidance (Laudien/Daxböck 2016).

Business model patterns are a practical solution for efficiently and systematically innovating business models (Amshoff et al. 2015). Gassmann et al. (2014) demonstrate that 90% of all business model innovations are combinations of patterns that have been there already. Business model patterns can serve as a common vocabulary for systematically presenting options for business model innovations (Bocken et al. 2014). Practitioners can use patterns to look for analogies (Gavetti/Rivkin 2005). Patterns can support creativity, inspiration, thinking out-of-the-box, and question industry standards or business logics (Remané et al. 2017b). We understand business model patterns as "the core of a recurring [business model] design problem and the corresponding [business model] design solution in such an abstract way that it can be applied in [business model]s of various firms from different industries and markets" (Weking et al. 2020b).

In research, business models, business model innovation, and business model patterns have received increasing attention and have challenged traditional strategy theories (Zott et al. 2011; Massa et al. 2017). The research did not yet come to one commonly used understanding of business models (Massa et al. 2017; Zott et al. 2011; Foss/Saebi 2017; Spieth/Schneider 2016; Schneider/Spieth 2013). Massa et al. (2017) identify three different interpretations: (1) attributes of real firms, (2) cognitive/ linguistic schemas, and (3) formal conceptual representations. For business model innovations, Foss/Saebi (2017) likewise identify four different usages in research: (1) its conceptualization, (2) its organizational change process, (3) its outcomes, and (4) its implications for organizational performance. Concerning business model patterns, there are several frameworks and conceptualizations. General frameworks include the Business Model Canvas (Osterwalder/Pigneur 2010), the Magic Triangle (Gassmann et al. 2014), the business model framework according to Abdelkafi et al. (2013), the unified business model framework (Al-Debei/Avison 2010), and the STOF model (Bouwman et al. 2008; de Reuver et al. 2013). Similarly, frameworks, taxonomies, and pattern collections have emerged for specific areas of application only.

Summarizing, research has established an initial understanding of business models, business model innovation, and business model patterns. However, we observe that current research does not reach far enough in front of practical problems with business model innovations. On the one hand, we experience various prospering digital business models (Parker et al. 2016; Gassmann et al. 2013; Gassmann et al. 2016; Afuah 2014). On the other hand, we see that many business model innovations fail, in particular in incumbent firms (Christensen et al. 2016).

Firms rely on experimentation instead of supporting tools, such as business model patterns (McGrath 2010; Chesbrough/Rosenbloom 2002; Sosna et al. 2010). Therefore, this thesis develops an empirical understanding of business model innovations by analyzing business model patterns and transformation paths between them. We have observed three remaining gaps in the literature, which we address in this thesis.

First, extant business model patterns in research show a high diversity and strong overlaps, and literature does not reveal their potential. While some business model patterns cover entire business models, such as the Merchant Model (Remané et al. 2017b), others describe only parts of a business model, such as Freemium (Remané et al. 2017b). In addition, patterns characterize diverse levels of abstraction. Some business model patterns show a low level of abstraction, such as the pattern Flexible Pricing (Remané et al. 2017b), whereas others address a high level of abstraction, such as the pattern Multi-sided Platform (Osterwalder/Pigneur 2010). These diversities in abstraction levels and covered business model elements cause patterns to overlap in content and substance. This results in a chaotic and scattered collection of business model patterns in literature, which prevents firms from using patterns in practice. Furthermore, research does not reveal the value of business model innovation and patterns yet. The discussion about how business models influence firm performance is driven by qualitative and highly contextual studies, partially in specific industries with limited generalizability (Lambert/Davidson 2013; Demil et al. 2015; Spiegel et al. 2015). To illustrate the potential of business model innovation and patterns, more industry-independent quantitative studies are needed (Lussier/Pfeifer 2001; Al-Debei/Avison 2010; Zott et al. 2011; Lambert/Davidson 2013; Foss/Saebi 2017). In sum, with the current state of research firms cannot use business model patterns and do not see their potential.

Second, research lacks an understanding of new emerging digital business model patterns. The literature on how industries under change influence business models and related patterns is still in its infancy (Remané et al. 2017b). Some initial examples are business model taxonomies and patterns for big data (Hartmann et al. 2016), FinTechs (Eickhoff et al. 2017), car-sharing (Remané et al. 2016c), multi-sided platforms (Täuscher/Laudien 2018), the Internet of Things (IoT) (Fleisch et al. 2014), digital business models (Bock/Wiener 2017), or sustainable business models (Upward/Jones 2016). Still, how many other industries or application areas under change influence business models remains unclear, in particular in traditional industries (Rayna/Striukova 2016; Bock/Wiener 2017). Two examples, where this thesis focuses on, are the manufacturing context with Industry 4.0 and blockchain technology. In both areas, research is technically-driven and does not cover the business perspective. Research on Industry 4.0 mainly covers its technological implications (Kiel et al. 2016; Burmeister et al. 2016). The literature about blockchain technology likewise mainly investigates technological aspects (Nakamoto 2008; Wang/Kogan 2018; Eyal/Sirer 2018) and its implementation in practice (Kshetri 2018; Jun/Vasarhelyi 2017; Radanović/Likić 2018). Hence, research does not guide firms on how to innovate business models in the context of Industry 4.0 or with the help of blockchain technology.

Third, research lacks an understanding of how firms transform between business model patterns. Research lacks transformation paths between business model patterns. In particular in manufacturing, firms are confronted with the pressure to follow servitization, which covers the business model innovation from product sales to providing integrated product-service systems (Adrodegari/Saccani 2017; Baines et al. 2009; Finne et al. 2013; Storbacka et al. 2013). However, research lacks an understanding of transformation paths and strategic guidance for manufacturing firms (Ardolino et al. 2018). Little is known about dependencies between different types of product-service systems before, during, and after a business model innovation and the possible influence of digital technologies (Adrodegari/Saccani 2017; Ardolino et al. 2018). Besides, research is dominated by in-depth single case studies on servitization and lacks cross-case investigations, which would provide more generalizable results (Annarelli et al. 2016; Brax/Visintin 2017). Furthermore, research lacks studies on the process of innovating and designing business models (Ebel et al. 2016). Also, research does not address how to integrate external stakeholders in these processes. Integrating external stakeholders can mitigate inhibiting cultures and releases new resources and capabilities that support business model innovation (Amit/Zott 2015). However, articles typically analyze one particular stakeholder group and neglect others (Kazadi et al. 2016; Driessen/Hillebrand 2013). If, when, and how firms integrate external stakeholders in business model innovation projects are rarely investigated.

1.2 Research Questions

To address the gaps outlined above, this thesis develops an empirical understanding of business model innovations of incumbent firms by analyzing business model patterns and transformation paths between patterns to support firms in business model innovation. We answer three research questions in this thesis:

RQ1: *How can firms leverage business model patterns for business model innovations?*

This research question covers two aspects. First, a systematic literature review on business model patterns provides a basis to develop a hierarchical taxonomy of patterns. The hierarchical structure of the taxonomy resolves the high diversity and overlaps between patterns from literature. It enables the usage of patterns and provides the basis for the whole thesis. Second, we show the value of business model patterns by quantitatively analyzing applied patterns and firm performance.

RQ2: *Which business model patterns emerge when incumbent firms innovate their business model?*

With the second research question, we empirically analyze new, emerging digital business model patterns. We build on case studies, case surveys, taxonomy development, and quantitative methods. We focus on the application areas: manufacturing firms in the context of Industry 4.0 and business models emerging from blockchain technology. Resulting business model taxonomies and business model patterns shape a static perspective on new, emerging digital business models.

RQ3: *What are transformation paths in business model innovations of incumbent firms?*

The third research question then leaves the static perspective on patterns and addresses the dynamic perspective on business model innovation. We build on multiple case studies to analyze two aspects: First, we investigate transformation paths between business model patterns, where we focus on manufacturing context, in particular, product-service systems. Second, we analyze business model innovation processes including tools and external stakeholder integration.

1.3 Structure

This thesis has three parts. Part A introduces the topic by motivating it, defining the research questions, and outlining the thesis structure (Chapter 1). Subsequently, we define and explain the needed constructs for this thesis in the conceptual background (Chapter 2). This includes business models, their relation to extant strategy theories, business model innovation, business model patterns, and transformation paths to describe innovations between business model patterns. Next, we present our research approach, which follows a pragmatic epistemological position and a mixed-method research strategy (Chapter 3).

In part B, we provide an overview of the seven published papers included in this thesis, which can be found in Appendix A in their original format. The first publication (P1) lays the foundation of this thesis by reviewing and structuring the literature according to business model patterns (Chapter 4). The second publication (P2) then analyzes the performance of the business model patterns and, thus, shows their practical applicability (Chapter 5). Based on that, we used three publications to identify new and emerging business model patterns. Publication three (P3) and four (P4) detect emerging business model patterns in the context of Industry 4.0 (Chapters 6 and 7). The fifth publication (P5) reveals new business model patterns that are driven by blockchain technology (Chapter 8). Building on the rather static perspective of patterns, the remaining two publications focus on transformation paths and innovation processes between business model patterns. The sixth publication (P6) reveals transformation paths in the context of product-service systems based on expert interviews (Chapter 9). Finally, publication seven (P7) builds on three case studies to investigate how firms can accomplish these business model innovations with the help of external stakeholders (Chapter 10).

Part C first summarizes the findings of the included papers (Chapter 11). Second, we discuss the results in front of the literature (Chapter 12). Third, we show the limitations of this thesis (Chapter 13). Fourth, we summarize the implications for theory and practice (Chapter 14). Fifth, we outline aspects of future research (Chapter 15). Finally, we briefly conclude the thesis (Chapter 16). Figure 1 summarizes the structure of this thesis.

Part A	**Introduction, Conceptual Background, and Research Approach**	
Part B	**Published Articles**	
	RQ1: How can firms leverage business model patterns for business model innovations?	
	P1	*A Hierarchical Taxonomy of Business Model Patterns* Method: Literature review, taxonomy development, quantitative methods
	P2	*Does Business Model Matter for Startup Success? A Quantitative Analysis* Method: Quantitative methods
	RQ2: Which business model patterns emerge when incumbent firms innovate their business model?	
	P3	*Archetypes for Industry 4.0 Business Model Innovations* Method: Taxonomy development, case study, case survey
	P4	*Leveraging Industry 4.0 – A Business Model Pattern Framework* Method: Taxonomy development, case study, case survey
	P5	*The Impact of Blockchain Technology on Business Models – A Taxonomy and Archetypal Patterns* Method: Taxonomy development, case study, case survey, quantitative methods
	RQ3: What are transformation paths in business model innovations of incumbent firms?	
	P6	*Business Model Innovation Strategies for Product Service Systems – An Explorative Study in the Manufacturing Industry* Method: Case study
	P7	*Practices for Open Business Model Innovation – An Innomediaries Perspective* Method: Case study
Part C	**Summary of Results, Discussion, Limitations, Implications, Future Research, and Conclusion**	

Figure 1. Structure of the Thesis

The following paragraphs and Table 1 summarize the seven publications that are part of this thesis (see Part B and Appendix A). We outline the motivation, aim, method, and main contributions of each paper.

P1: A Hierarchical Taxonomy of Business Model Patterns (Weking et al. 2018b). This publication addresses the problem of various unstructured literature on business model patterns with a high diversity of patterns and overlaps. In the paper, we give an overview and structure extant business model patterns in a hierarchical taxonomy, which includes inheritance with generalizations and specializations. We use a literature review, taxonomy development, and quantitative methods to develop the taxonomy. For research, the taxonomy supports describing business models and using them as theoretical constructs. For practice, the taxonomy with its structure eases the understanding and application of business model patterns and, thus, supports business model innovations.

P2: Does Business Model Matter for Startup Success? A Quantitative Analysis (Weking et al. 2019a). In this paper, we address the problem that qualitative research dominates the literature on the relationship between business models and firm performance. Research lacked quantitative studies on business models and firm performance. Therefore, we used a set of 500 startups to investigate their applied business model patterns and their survival after two years as an indicator for firm performance. We found two patterns significantly correlating with a higher survival rate, i.e., Freemium and Subscription, and four patterns significantly correlating with a lower survival rate, i.e., Cross Selling, Hidden Revenue, Layer Player, and No Frills. For research, we underline the role of business models as a theoretical construct by showing that they matter for firm performance. For practice, we demonstrate initial patterns that correlate with increased or decreased chances of survival for startups.

P3: Archetypes for Industry 4.0 Business Model Innovations (Weking et al. 2018c). This study develops a business model perspective for the technical-driven literature on the digital transformation of manufacturing industries, i.e., Industry 4.0. We developed an initial business model taxonomy and business model patterns for firms transforming towards the fourth industrial revolution. We used 15 case studies to derive three overarching high-level business model patterns and ten underlying patterns for Industry 4.0. For research, we shed light on how traditional industries can transform. For practice, we showed initial guidance on how manufacturing firms can adopt Industry 4.0 business models.

P4: Leveraging Industry 4.0 – A Business Model Pattern Framework (Weking et al. 2020b). In this publication, we revised, enriched, and deepened findings of the publication P3. We increased the number of case studies to 32, revised the taxonomy and patterns, and added four different evaluations. We identified three overarching, archetypal business model patterns: Integration, Servitization, and Expertization. The taxonomy and pattern contribute to research by enabling the description, analysis, and classification of business models in the Industry 4.0 context. In this way, the taxonomy and patterns lay out the foundations to ensure construct clarity in future research. In practice, the taxonomy and patterns can be used for assessing the readiness of a firm for Industry 4.0 and for illustrating business model opportunities.

P5: The Impact of Blockchain Technology on Business Models – A Taxonomy and Archetypal Patterns (Weking et al. 2019b). This study addresses the problem that the understanding of research and practice on how to leverage blockchain technology for business is still poor. Therefore, we developed a business model taxonomy and patterns for leveraging blockchain technology. We built on a case survey with 99 firms that already incorporate blockchain technology as the core of their business model. The taxonomy and patterns enrich the understanding of research on how blockchain technology changes business models and provide the basis for future research. For practice, we provide practical guidance on how firms can use blockchain technology to innovate their business model.

P6: Business Model Innovation Strategies for Product Service Systems – An Explorative Study in the Manufacturing Industry (Weking et al. 2018a). In this publication, we change the perspective from rather static business model patterns towards business model innovations and their transformation paths. We addressed the problem of how firms can innovate towards or within business models for product-service systems in the manufacturing industry. Therefore, we interviewed 14 business managers in this domain. We identified three evolutionary and three transformative transformation paths. These paths extend extant research on goods- and service-dominant logic with cases on how business model innovations can take place within the domain of the product-service systems. For practice, findings indicate guidance on how firms can transform and can support identifying opportunities for a firm.

P7: Practices for Open Business Model Innovation – An Innomediaries Perspective (Weking et al. 2020a). In this publication, we addressed the problem of the enormous number of failing business model innovations in practice. We identified a new role of intermediaries that are specialists in business model innovations, so-called “Innomediaries”. We conducted three in-depths case studies with three innomediaries. We developed a practice-oriented framework for integrating external stakeholders in business model innovations. In this way, we contribute to the literature on business model innovation and open innovation, while combining both with the new role of innomediaries. For practice, the framework guide firms when to integrate whom and how in business model innovations to speed-up projects and increase their success.

RQ	No.	Authors	Title	Outlet	Type
RQ1	P1	Weking, Hein, Böhm, Krcmar	A Hierarchical Taxonomy of Business Model Patterns	EM	JNL (VHB: B)
	P2	Weking, Böttcher, Hermes, Hein	Does Business Model Matter for Startup Success? A Quantitative Analysis	ECIS 2019	CON (VHB: B)
RQ2	P3	Weking, Stöcker, Kowalkiewicz, Böhm, Krcmar	Archetypes for Industry 4.0 Business Model Innovations	AMCIS 2018 (Best Paper Award 1st Runner-up)	CON (VHB: D)
	P4	Weking, Stöcker, Kowalkiewicz, Böhm, Krcmar	Leveraging Industry 4.0 – A Business Model Pattern Framework	IJPE	JNL (VHB: B)
	P5	Weking, Mandalenakis, Hein, Hermes, Böhm, Krcmar	The Impact of Blockchain Technology on Business Models – A Taxonomy and Archetypal Patterns	EM	JNL (VHB: B)
RQ3	P6	Weking, Brosig, Böhm, Hein, Krcmar	Business Model Innovation Strategies for Product Service Systems – An Explorative Study in the Manufacturing Industry	ECIS 2018	CON (VHB: B)
	P7	Weking, Lupberger, Hermes, Hein, Böhm, Krcmar	Practices for Open Business Model Innovation – An Innomediaries Perspective	WI 2020	CON (VHB: C)

Outlet:
EM: Electronic Markets
ECIS: European Conference on Information Systems
AMCIS: Americas Conference on Information Systems
IJPE: International Journal of Production Economics
WI: Internationale Tagung Wirtschaftsinformatik

Type:
CON: Conference
JNL: Journal
VHB: German Academic Association for Business Research

Table 1. Embedded Publications

In addition to the seven publications embedded in this dissertation, we conducted further studies that relate indirectly to the research questions above (see Table 2). These articles complement the results of the embedded publications and are often led by co-authors. Related to RQ1, we investigated the relationship of firms' applied business model patterns and their performance based on data mining techniques (Böhm et al. 2017) and a survey with startups (Haddad et al. 2020). We further studied the relationship of specific business model characteristics on the funding received by startups (Böhm et al. 2019).

Related to RQ2, we investigated emerging business model patterns for highly autonomous consumer buying agents (Weber et al. 2020). Besides, we analyzed digital platforms as one specific emerging business model pattern that has become increasingly important in research and practice. We studied their market dominance (Hermes et al. 2020b; Hermes et al. 2020c) and detailed platform business model patterns that are successful and still emerging (Hein et al. 2019a).

Related to RQ3, we determined antecedents and outcomes of business model innovations in general, which complement our research on transformation paths (Böttcher/Weking 2020). We additionally explored how firms innovate towards successful platform business models (Hein et al. 2019b) and developed a design framework for service-platform business models (Hein et al. 2018). In addition, we studied how firms leverage and innovate their platform business model to dethrone established players (Hermes et al. 2020a). Further studies cover possible transformation paths towards business models that incorporate the IoT to offer product-service systems (Basirati et al. 2019b, 2019a).

While the selected seven publications embedded in this thesis (P1-P7) comprehensively answer the three research questions, these additional publications supplement our results with additional contexts, lenses, and related research areas or narrowed-down research topics.

RQ	Authors	Title	Outlet	Type
RQ1	Böhm, Weking, Fortunat, Müller, Welpe, Krcmar	The business model DNA: Towards an approach for predicting business model success	WI 2017	CON (VHB: C)
	Haddad, Weking, Hermes, Böhm, Krcmar	Business Model Choice Matters: How Business Models Impact Different Performance Measures of Startups	WI 2020	CON (VHB: C)
	Böhm, Hein, Hermes, Lurz, Poszler, Ritter, Soto Setzke, Weking, Welpe, Krcmar	Die Rolle von Startups im Innovationssystem. Eine qualitativempirische Untersuchung. Studien zum deutschen Innovationssystem	EFI 2019	Report (VHB: NR)
RQ2	Weber, Kowalkiewicz, Weking, Böhm, Krcmar	When Algorithms Go Shopping: Analyzing Business Models for Highly Autonomous Consumer Buying Agents	WI 2020	CON (VHB: C)
	Hermes, Pfab, Hein, Weking, Böhm, Krcmar	Digital Platforms and Market Dominance: Insights from a Systematic Literature Review and Avenues for Future Research	PACIS 2020	CON (VHB: C)
	Hermes, Töller, Hein, Weking	Gaining Control over Critical Platforms: A Comparative Case Study of European Consortia	ECIS 2020	CON (VHB: B)
	Hein, Soto Setzke, Hermes, Weking	The Influence of Digital Affordances and Generativity on Digital Platform Leadership	ICIS 2019	CON (VHB: A)
RQ3	Böttcher, Weking	Identifying Antecedents and Outcomes of Digital Business Model Innovation	ECIS 2020	CON (VHB: B)
	Hein, Weking, Schreieck, Wiesche, Böhm, Krcmar	Value co-creation practices in business-to-business platform ecosystems	EM	JNL (VHB: B)
	Hein, Scheiber, Böhm, Weking, Krcmar	Toward a Design Framework for Service-Platform Ecosystems	ECIS 2018	CON (VHB: B)
	Hermes, Kaufmann-Ludwig, Schreieck, Weking, Böhm	A Taxonomy of Platform Envelopment: Revealing Patterns and Particularities	AMCIS 2020	CON (VHB: D)
	Basirati, Weking, Hermes, Böhm, Krcmar	IoT as PSS Enabler: Exploring Opportunities for Conceptualization and Implementation	PACIS 2019	CON (VHB: C)
	Basirati, Weking, Hermes, Böhm, Krcmar	Exploring Opportunities of IoT for Product–Service System Conceptualization and Implementation	APJIS	JNL (VHB: NR)

Outlet:
AMCIS: Americas Conference on Information Systems
APJIS: Asia Pacific Journal of Information Systems
ECIS: European Conference on Information Systems
EM: Electronic Markets
EFI: Expertenkommission Forschung und Innovation
PACIS: Pacific Asia Conference on Information Systems
WI: Internationale Tagung Wirtschaftsinformatik

Type:
CON: Conference
JNL: Journal
NR: Not ranked
VHB: German Academic Association for Business Research

Table 2. Additional Publications, not Embedded in the Thesis

2 Conceptual Background

In this section, we describe the theoretical foundations for this thesis. We define the concepts of business models and elaborate on their connection to traditional strategy theories before we discuss business model innovations, business model patterns, and transformation paths.

2.1 Business Models

Despite the growing attention of business models and business model innovation in practice and rapidly increasing research on these concepts, research did not reach a commonly used understanding and interpretation of business models yet (Massa et al. 2017). Several literature reviews show different understandings and research streams of the concept (Massa et al. 2017; Zott et al. 2011; Foss/Saebi 2017; Spieth/Schneider 2016; Schneider/Spieth 2013). Research on business models mainly builds on three different interpretations of the concept: "(1) business models as attributes of real firms, (2) business models as cognitive/ linguistic schemas, and (3) business models as formal conceptual representations of how a business functions" (Massa et al. 2017). We elaborate on each of the interpretations in the following.

The first research stream interprets business models as attributes of existing firms and as a real-world phenomenon, which can be empirically investigated (Massa et al. 2017). Characteristics are measured and not conceptually proposed. Scholars following this interpretation define the business model concept as a "set of activities, as well as the resources and capabilities to perform them – either within the firm, or beyond it through cooperation with partners, suppliers or customers" (Zott/Amit 2010) or as a "firm's underlying core logic and strategic choices for creating and capturing value within a value network" (Shafer et al. 2005).

The second research stream understands business models as cognitive/ linguistic schemas, i.e., narratives (Massa et al. 2017). Managers follow their cognitive frames that shape their image of business models. Hence, business models are an established thinking pattern or a dominant logic held by organizational members. A comprehensive definition of business models covers "cognitive structures that consist of concepts and relations among them that organize managerial understandings about the design of activities and exchanges that reflect the critical interdependencies and value creation relations in their firms' exchange networks" (Martins et al. 2015).

The third research stream sees the business model as formal conceptual representations (Massa et al. 2017). This interpretation is situated between the first two. Whereas the second interpretation is an implicit model of an actual system, the third interpretation is rather an explicit, graphic, and symbolic representation. Business models as formal conceptual models aim to cover tacit knowledge and reduce complexity by abstracting and simplifying. Examples are early frameworks (Osterwalder et al. 2005), the business model canvas (Osterwalder/Pigneur 2010, 2002; Osterwalder 2004), and the magic triangle (Gassmann et al. 2014).

To investigate business model innovations, business model patterns, and transformation paths, this thesis follows the interpretation of business models as formal conceptual models (Massa et al. 2017). This interpretation allows us to reduce complexity by describing business models with abstract business model taxonomies and business model patterns. Taxonomies allow us to determine relevant dimensions for specific contexts, while patterns enable aggregations in abstract, widely applicable solutions.

To generate business model taxonomies and patterns for specific contexts as formal conceptual representations, we can build on different general abstract business model components. Different definitions directly or indirectly comprise the four components depicted in Table 3 and how these components are interrelated. Theoretical approaches (Foss/Saebi 2017; Saebi et al. 2017; Teece 2010) as well as practical approaches (Osterwalder/Pigneur 2010; Gassmann et al. 2014) support these four components.

Foss/Saebi (2017), Saebi et al. (2017)	Teece (2010)	Osterwalder/Pigneur (2010)	Gassmann et al. (2014)
Market segments	Customers	Customer segments	Who is the target customer?
Value proposition	Value	Value proposition	What does the customer value?
Structure of the value chain	Value creation Value delivery	Key partners Key activities Key resources Customer relationships Channels	How is the value proposition built and distributed?
Value capture mechanisms	Value capture mechanisms	Revenue streams Cost structure	Why is the BM financially viable?

Table 3. Components of Business Models (Weking et al. 2020b)

As we follow slightly different definitions throughout the publications of this thesis, they largely converge with the understanding of business models as "the design or architecture of the value creation, delivery, and capture mechanisms [a firm] employs" (Teece 2010) and "how the enterprise creates and delivers value to customers, and then converts payments received to profits" (Teece 2010).

2.2 Business Models and Traditional Strategy Theories

There are two predominant strategy theories, which also have been frequently discussed with business models: the positioning view and the resource-based view including dynamic capabilities (McGrath 2010; Massa et al. 2017).

The positioning view has long suggested that to be successful, firms must find a truly differentiated as well as defensible spot in an industry and work tirelessly against this position (Porter 1980, 2008). Five forces characterize this position and the attractiveness of a market: the "bargaining power of buyers", the "bargaining power of suppliers", the "threat of new entrants", the "threat of substitute products or services", and the "rivalry among existing competitors" (Porter 2008). A firm can then follow three generic strategies out of its position: "cost leadership, differentiation, and focus" (Porter 2008).

The second predominant strategy theory is the resource-based view. Here, the competitive advantage of a firm and its long-term performance stems from and is enabled by the resources the firm possesses (Barney 1991). Resources have to be valuable, rare, imitable, and sustainable so that they can support firms to generate sustained competitive advantage (Barney 1991). To additionally capture how to develop, integrate and release these unique resources, Teece et al. (1997) extend this view with dynamic capabilities, which are defined "as the firm's ability to integrate, build, and reconfigure internal and external competencies to address rapidly-changing environments”. Recently, Teece (2018) discusses the relationships between dynamic capabilities and business models. He proposes that business models, dynamic capabilities, and strategy are three interdependent aspects of a firm.

However, one research stream uses the business model concept similar to strategy (Casadesus-Masanell/Zhu 2013; Casadesus-Masanell/Ricart 2010; Markides/Sosa 2013; Markides 2013) and partly argues that the business model addresses known strategy concepts with a new term (e.g. Porter 2001). But, there are significant differences between traditional strategy theories and the business model (Massa et al. 2017). First, from a business model perspective, one always starts with the value proposition, then value delivery and finally they think about how to monetize it. Traditional strategy theories assume that if a firm delivers value to customers, they will at all times pay for it (Teece 2010). From a business model perspective, it is not sure if customers will pay for the value that is delivered (Massa et al. 2017). Online basic services are expected to be free. Second, traditional theories focus on value for shareholders, whereas business model research focuses on the value for customers and partners (Amit/Zott 2001). Partners and customers can further contribute on the basis on network externalities, for example (McIntyre/Srinivasan 2017; Parker et al. 2017; Hein et al. 2020). Third, while traditional strategy theories assume perfect information, the business model concept assumes that the knowledge of a firm, of its customers, and of its partners is limited and biased (Massa et al. 2017). Continuous adaptations and experiments are needed instead of positioning or managing resources (Chesbrough/Rosenbloom 2002; McGrath 2010).

In this way, the business model concept can challenge some assumptions of traditional strategy theories. First, business models challenge the assumption of firms and their customers having perfect information by building on information asymmetries. Second, business models challenge the assumption of firms and their customers having unlimited cognitive abilities. Third, business models challenge the assumption of no externalities, i.e. a transaction between a firm and a customer does not influence third parties. Fourth, business models concentrate on value creation in the supply side and demand side. A business model is embedded between a firm and its value network, whereas traditional theories focus on the supply-side of value capture only. In this way, the business model can clearly differentiate itself from strategy as its own theoretical construct.

2.3 Business Model Innovation

Business model innovation is about changes in a business model of a firm. This research stream identifies the business model itself as a possible cause of innovation similar to a product, a process, a service, or an organizational innovation (Foss/Saebi 2017; Zott et al. 2011). Business model innovations are defined as “designed, novel, nontrivial changes to the key elements of a firm’s business model and/or the architecture linking these elements” (Foss/Saebi 2017). “Designed” shows that business model innovation implies a conscious decision to innovate and “Novel, non-trivial changes” further clarifies that a certain level of novelty is needed for business model innovation.

In their literature review, Foss/Saebi (2017) identify four streams of research addressing business model innovations on which we build and expand. The first stream covers the conceptualization of business model innovation (Amit/Zott 2012; Teece 2010). Research aims to find suitable definitions and dimensions. The second stream analyses business model innovation as an organizational change process including its stages (Frankenberger et al. 2013; de Reuver et al. 2013), capabilities (Teece 2018; Achtenhagen et al. 2013; Demil/Lecocq 2010), the relevance of experimentation (Andries/Debackere 2013; Sosna et al. 2010; Cavalcante 2014; Günzel/Holm 2013; Chesbrough/Rosenbloom 2002; McGrath 2010), and practice-oriented tools (Szopinski et al. 2019). The third, rather descriptive research stream, deals with the outcome of business model innovations, i.e., innovative, new business models, for example for disruptive technologies (Amshoff et al. 2015), for Servitization (Visnjic Kastalli/Van Looy 2013; Visnjic Kastalli et al. 2013; Visnjic Kastalli et al. 2016), for sustainability (Lüdeke-Freund et al. 2018), or for mobility (Remané et al. 2016b; Remané et al. 2016a; Abdelkafi et al. 2013). The fourth research stream investigates the organizational performance of business model innovations with direct effects of business model innovations (Cucculelli/Bettinelli 2015; Giesen et al. 2007; Bock et al. 2012; Aspara et al. 2010) or performance of different business models (Zott/Amit 2007, 2008; Weill et al. 2005; Weill et al. 2011). In this thesis, we address business model innovation mainly from an organizational change perspective.

In practice, business model innovation differs from strategy development in several ways. Building on analytical-driven strategy research, firms look for a suitable market and position themselves in it (Massa et al. 2017). Or, firms have hard-to-copy resources, which they control and manage (Massa et al. 2017). Business model innovation is different. Business model innovation is mainly driven by experimentation instead of rigorous planning (McGrath 2010). Since many environmental factors (e.g., market or technology) are unclear, firms continuously develop and test business models as hypotheses (Chesbrough/Rosenbloom 2002; Sosna et al. 2010). They use trial-and-error and gather feedback from customers and markets (Andries/Debackere 2013). Firms follow a path of failures and learning on their own as well as with partners (McGrath 2010). In this way, firms iteratively adapt and develop their business model. Thus, business model innovation works best in highly volatile and fast-changing environments (McGrath 2010). However, still many business model innovation initiatives fail (Christensen et al. 2016; Sosna et al. 2010) and approaches lack systematic guidance (Laudien/Daxböck 2016).

2.4 Business Model Patterns

We use different business model concepts with different levels of abstraction in this thesis. Figure 2 shows the relationships between these different concepts (Osterwalder et al. 2005). On the highest level of abstraction, we have the business model concept itself. It defines what a business model is and the elements that constitute a business model (see section 2.1). On the second-highest level of abstraction, we see business model patterns and their common characteristics. On this level, we also develop taxonomies of business model patterns (P1) and taxonomies of specific business models, e.g., Industry 4.0 (P3 and P4) or blockchain (P5). The third-highest level of abstraction describes modeled business model instances of real-world firms. An example is the Business Model Canvas or Magic Triangle filled in with information about a firm's business model. On the least level of abstraction, we then find the real-world firm.

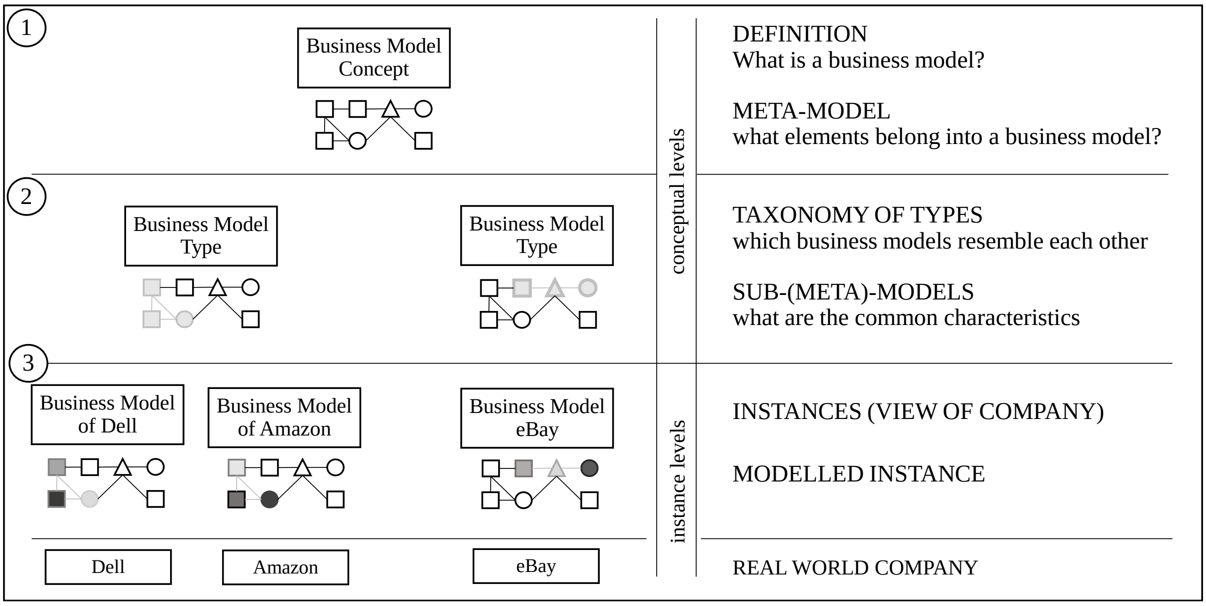

Figure 2. Business Model Concepts (adapted from Osterwalder et al. 2005)

Patterns have been discussed in several contexts. In general, patterns define a reoccurring problem and its solution (Alexander 1977). Thereby, patterns have a level of abstraction so that they can be applied repeatedly in different situations (Alexander 1977). In the context of business models, a business model pattern can be defined as “the core of a recurring [business model] design problem and the corresponding [business model] design solution in such an abstract way that it can be applied in [business model]s of various firms from different industries and markets” (Weking et al. 2020b). By applying the pattern to specific requirements of a firm, firms can reuse patterns (Abdelkafi et al. 2013; Amshoff et al. 2015; Remané et al. 2017b; Osterwalder/Pigneur 2010). Thus, business model patterns are recurring building blocks that abstractly reveal the business model logic (Rudtsch et al. 2014; Amshoff et al. 2015) and can result from a business model innovation process (Massa/Tucci 2014).

This thesis builds on business model patterns to analyze emerging business models in different contexts. Gassmann et al. (2014) propose that 90% of business model innovations in practice are combinations of already existing business model patterns. Hence, business model patterns can increase guidance and can serve as a tool supporting business model innovation initiatives (Amshoff et al. 2015). Patterns can stimulate creativity and inspiration, support thinking out-of-the-box, and can help to overcome and challenge industry standards or a predominant business logic (Remané et al. 2017b). Practitioners can think through who their firm would look like when applying a certain business model pattern.

There are several examples of business model patterns. Freemium, for example, is about offering “basic services for free, while charging a premium for advanced or special features” (Weking et al. 2018b). Typical use cases of this pattern are mobile apps that have a free and premium version. Another example is the Multi-sided Platform. Here, a provider brings “together two or more distinct but interdependent groups of customers, where the presence of each group creates value for the other groups” (Weking et al. 2018b). Common use cases are app stores. App stores build on complementors that provide apps for users. Another example of a business model pattern is the Add-on pattern, which is about offering “a basic product at a competitive price and charge for several extras" (Weking et al. 2018b). Low-cost airlines heavily build on this pattern. Flights are offered very cheaply, but they charge for luggage or preferred seating.

2.5 Transformation Paths

When firms innovate from one business model to another, they can typically choose from different transformation paths (Khanagha et al. 2014). Transformation paths can capture the change process from a business model pattern A to a business model pattern B (Bock/Wiener 2017). Hereby, firms can use different paths to transform from one business model to another (Kindström 2010; Bustinza et al. 2017; Berman 2012). If firms aim for revolutionary substituting their current business model, flexible and decentralized structures might be necessary, whereas a slow evolution of an existing business model might require efficient and centralized structures (Khanagha et al. 2014). Even when firms targeting a similar business model, the transformation paths for accomplishing the change can vary significantly (Bustinza et al. 2017).

In the servitization context, for example, firms transform from a product-oriented focus towards a service-oriented focus (Adrodegari/Saccani 2017). In particular industrial firms follow this kind of service transformation (Adrodegari/Saccani 2017). The linear product-service continuum describes how a firm transforms from a clear product-oriented business model towards a service-oriented business model by steadily increasing service offerings and stepwise and gradually changing their business model (Brax/Visintin 2017). Within this transformation, there are again different transformation paths. Some firms, for example, consolidate services in a shared service center to increase flexibility, while others do not (Su et al. 2009). In addition, research has identified additional transformation paths for servitization in contrast to the linear, gradual transformation along the product-service continuum (Adrodegari/Saccani 2017; Ardolino et al. 2018). Here, research is still in its infancy and more studies are needed to investigate further transformation paths of business models in the servitization context (Adrodegari/Saccani 2017).

To analyze the process of change in business model innovations and related patterns, we, thus, build on transformation paths. We use developed patterns and taxonomies of this thesis to describe the paths in detail.

3 Research Approach

To investigate business model innovations and underlying business model patterns and transformation paths, we use a pragmatic epistemological stance and a mixed-method strategy of inquiry. We combine qualitative and quantitative approaches by using iterative taxonomy development based on empirical and conceptual findings, case studies, case surveys, cluster analyses, and contingency analyses.

3.1 Pragmatic, Mixed Method Research Strategy

The pragmatic epistemological position does not follow the theory of other epistemological positions, namely positivist, interpretative, and critical. Pragmatism assumes that qualitative and quantitative research approaches are compatible (Teddlie/Tashakkori 2010). The pragmatic stance challenges the separation of positivism and constructivism and suggests to converge qualitative and quantitative research approaches (Feilzer 2010). Research questions are of central relevance, not the methods used (Teddlie/Tashakkori 2010). For a comprehensive understanding of a phenomenon, both qualitative and quantitative methods are often needed (Johnson/Onwuegbuzie 2004). Pragmatism does not talk about meta concepts, such as reality or truth, but places importance on the usefulness of research (Teddlie/Tashakkori 2010; Feilzer 2010). Thus, the pragmatic research philosophy is very applied and practical (Teddlie/Tashakkori 2010). The paradigm does not constrain researchers in terms of mental and practical restrictions, such as adhering to a particular research approach (Feilzer 2010). In this way, the pragmatic paradigm emerged as the ideally suited research philosophy in mixed-method research (Venkatesh et al. 2013).

Mixed-method research approaches come with several benefits (Venkatesh et al. 2013; Venkatesh et al. 2016). It combines the advantages of qualitative and quantitative methods and mitigates the limitations of both methods. Mixed-method research can approach both exploratory and confirmatory research questions at the same time. In this way, mixed-method research can develop “meta-inferences” (Venkatesh et al. 2013). Meta-inferences integrate results of qualitative and quantitative studies and, thus, constitute new theoretical perspectives that are richer than findings resulting from one research approach or world view (Venkatesh et al. 2013). Mixed-methods provide a platform for a variety of paradigms and views.

This thesis builds on mixed-method research to get a rich and comprehensive understanding of business model innovation, patterns, and transformation paths. We apply several methods. Regarding qualitative methods, we use case studies, case surveys, and qualitative content analysis, such as taxonomy development and qualitative cluster analysis. Regarding quantitative methods, we use cluster analyses, contingency tables, chi-square tests, and Fisher’s exact tests. Additionally, we combine qualitative and quantitative approaches, for example, by integrating case studies and case surveys.

3.2 Research Methods

Following a pragmatic paradigm with a mixed-method strategy of inquiry, the main methods of this thesis are case studies and surveys (P3 – P7) and taxonomy development (P1, P3 - P5) (see Table 4). Moreover, this thesis builds on a literature review (P1) and quantitative methods, such as cluster analyses (P1 and P5) and contingency analysis (P2) (see Table 4). The following elaborates on the background for each of the methods. Furthermore, each of the publications provides a detailed description of how methods have been applied.

Publication	Lit. Review	Taxon-omy Dev.	Case Study	Case Survey	Quant. Meth-ods
A Hierarchical Taxonomy of Business Model Pat-terns (P1)	X	X			X
Does Business Model Matter for Startup Success? A Quantitative Analysis (P2)					X
Archetypes for Industry 4.0 Business Model Inno-vations (P3)		X	X	X	
Leveraging Industry 4.0 – A Business Model Pat-tern Framework (P4)		X	X	X	
The Impact of Blockchain Technology on Business Models – A Taxonomy and Archetypal Patterns (P5)		X	X	X	X
Business Model Innovation Strategies for Product Service Systems – An Explorative Study in the Manufacturing Industry (P6)			X		
Practices for Open Business Model Innovation – An Innomediaries Perspective (P7)			X		

Table 4. Research Methods of the Publications

3.2.1 Literature Review

Literature reviews are essential to advance and contribute to existing knowledge (Webster/Watson 2002). Researches need to locate, understand, and synthesize existing research on a topic of interest to create a foundation for new research projects (vom Brocke et al. 2015; Cooper 1988). In this way, they can derive theories and conceptual backgrounds for their research and build on and extend what has been done (Paré et al. 2015). Moreover, literature reviews reveal research gaps and, thus, support finding ideas for future research (Paré et al. 2015).

Several types of reviews exist: narrative reviews, descriptive reviews, scoping/mapping reviews, meta-analyses, qualitative systematic reviews, umbrella reviews, theoretical reviews, realist reviews, and critical reviews (Paré et al. 2015). Most of the reviews published in information systems literature are theoretical. Theoretical reviews aim at explanation building and developing a higher-level theoretical conceptual structure (Webster/Watson 2002). Hence, theoretical reviews can build new theoretical insights out of existing research.

A theoretical review follows a systematic data collection and data analysis process (Paré et al. 2015). Data collection aims at identifying a set of relevant articles in five steps (vom Brocke et al. 2009). First, authors need to determine relevant outlets, i.e., journals and conference proceedings. The second step identifies relevant databases that cover the selected outlets. Third, researchers develop and use a set of keywords to search for articles in the selected databases, which leads to an initial set of possibly relevant papers. The fourth step is about backward and forward searches to ensure that the set of papers includes all relevant papers for this topic. In the backward search, researchers screen all references of the identified articles for additional relevant articles. In the forward search, authors have a look at all papers citing the current set of relevant articles and screen them for additional papers. Fifth, to evaluate if a paper is relevant or not, researchers screen the title in the first round, abstract in the second, and full-text in the third (vom Brocke et al. 2009). In this way, data collection follows a systematic process.

For data analysis, several methods for synthesizing the literature are available for theoretical reviews (Paré et al. 2015). Webster/Watson (2002) suggest a systematic approach building on a concept matrix. In contrast to an author-centric approach, which structures and summarizes research streams along with authors, they suggest a concept-centric approach. When using the concept-centric approach, researchers identify common concepts in a set of papers and develop a concept matrix with concepts on the x-axis and papers on the y-axis. The matrix reveals important concepts discussed in many papers as well as blind spots or research gaps in the literature. Thus, the concept matrix helps to summarize the literature and to discuss areas for future research.

In our study “A Hierarchical Taxonomy of Business Model Patterns” (P1), we build on a theoretical literature review to identify and synthesize the main concept of business model research and business model patterns (Weking et al. 2018b). We used the results of this review including a basic set of business model patterns as a basis for our subsequent research.

3.2.2 Iterative Taxonomy Development

To structure existing and derive new business model patterns, we used iterative taxonomy development in four of seven studies. Classifications, such as typologies or taxonomies, are essential for structuring knowledge and are the foundation for theory building (Rich 1992; Doty/Glick 1994). Knowledge and research of a field structured and organized in a taxonomy help researchers to investigate relationships among objects and, thus, support developing hypotheses and theories (Glass/Vessey 1995; McKnight/Chervany 2001).

Nickerson et al. (2013) suggest a seven-step process to develop taxonomies, which involves both conceptual and empirical strategies (see Figure 3). In the first step, researchers need to identify meta-characteristics. The meta-characteristic is the most wide-ranging characteristic of the type of objects that should be described and serves as a basis for subsequent dimensions and characteristics. Thus, meta-characteristics are strongly bound to the overall purpose of the taxonomy. Step two covers defining the ending conditions for the iterative approach. Nickerson et al. (2013) suggest objective (e.g. mutually exclusive, collectively exhaustive, and no changes in the last iteration) and subjective ending conditions (i.e., concise, robust, comprehensive, extendible, and explanatory). After the first two steps, the iterative approach (steps three to seven) begins. In step three, researchers need to decide if they start with an empirical or conceptual approach. Nickerson et al. (2013) recommend starting with a conceptual iteration if researchers have comprehensive domain knowledge and little data is available. If researches have significant data available but limited understanding of the domain, they should start with an empirical iteration. Steps four to six then cover developing and revising the taxonomy, either starting with empirical data, i.e., the objects that should be classified (empirical to conceptual approach), or starting with a conceptualization (conceptual to empirical approach). Finally, in step seven researchers decide whether ending conditions are met or another iteration is needed.

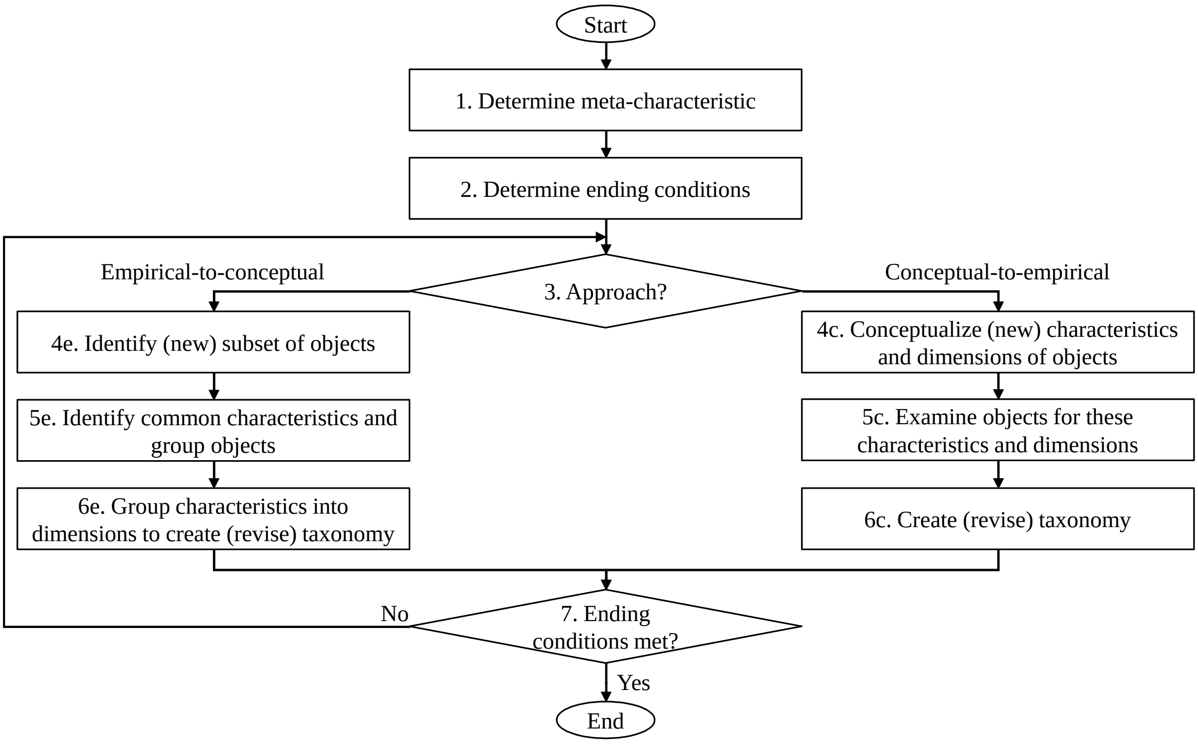

Figure 3. Taxonomy Development Method (Nickerson et al. 2013)

We applied the taxonomy development method according to Nickerson et al. (2013) in our studies “A Hierarchical Taxonomy of Business Model Patterns” (P1) (Weking et al. 2018b), “Archetypes for Industry 4.0 Business Model Innovations” (P3) (Weking et al. 2018c), “Leveraging Industry 4.0 – A Business Model Pattern Framework” (P4) (Weking et al. 2020b), and “The Impact of Blockchain Technology on Business Models – A Taxonomy and Archetypal Patterns” (P5) (Weking et al. 2019b). While we used the taxonomy development method in P1 to organize existing business model patterns from literature in a hierarchical structure, in P3 – P5 we used the method to develop new business model patterns based on cases from practice.

3.2.3 Case Study

To study new business model patterns, business model innovations, and transformation paths, we used guidelines of case study research in five of seven studies. Case studies constitute the most published form of qualitative approaches in information systems research as well as in management and business research (Recker 2013). Case study research can be used to provide rich descriptions of a phenomenon, develop a theory (Eisenhardt 1989; Eisenhardt/Graebner 2007), and test theory (Benbasat et al. 1987; Darke et al. 1998).

Case studies intensively investigate a specific phenomenon within its context to a certain point of time or period (Yin 2014). Typically, the phenomenon is contemporary and researchers analyze it in its natural setting. Boundaries between the phenomenon and its context can be fuzzy. That is why case studies rely on multiple ways of collecting data (e.g. interviews, observations, or secondary data). The different data collection approaches should then converge to reach data triangulation (Recker 2013). Yin (2014) suggests six iterative steps for conducting case study research (see Figure 4).

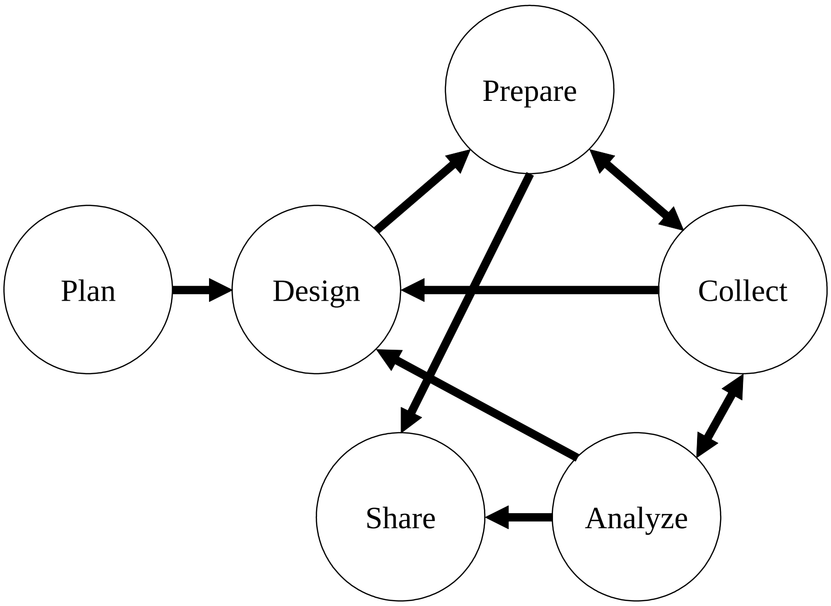

Figure 4. Case Study Procedure (Yin 2014)

Planning is about determining the research questions and evaluating the appropriateness of the case study approach for the defined questions. Case studies suit best to answer questions of "how" and "why" (Yin 2014). Researchers need a theoretical understanding of the problem at this stage to define suitable research questions. Furthermore, researchers have to decide whether to develop a theory or test a theory in this step.

Designing covers defining the number of cases and their unit of analysis (Yin 2014). Design options for the unit of analysis are a single unit of analysis, i.e., holistic design, or multiple units of analysis, i.e., embedded design. The number of case studies distinguishes single-case designs from multiple-case designs. In this way, Yin (2014) defines four types of case studies: single-case holistic, multiple-case holistic, single-case embedded, and multiple-case embedded. The design step additionally covers the development of a case study protocol including interview guidelines and case databases, for example.

In the **preparation** step, researchers refine their data collection skills, such as interviewing and observing. The case study protocol and guidelines should be finalized and pre-tested with a pilot case study, for example (Yin 2014). Moreover, this step covers defining the sampling strategy. The sampling strategy can be theoretical or selective (Eisenhardt/Graebner 2007). For theoretical sampling, the researcher collects and analyzes data and in parallel decides on the next data sources and develops a theory. For selective sampling, the researcher decides on data and cases beforehand based on pre-defined criteria and can develop a theory after data collection and analysis.

Collecting is about conducting the case study protocol (Yin 2014). Researchers should rely on multiple data sources to triangulate the data and support construct validity. Examples are interviews, internal documents, archival data, and observations. Interviews are the most common data collection technique (Eisenhardt/Graebner 2007). Researchers should record and transcribe them to support a comprehensive case database.

Analyzing data in case study research includes examining, categorizing, coding, tabulating, testing, or combining the data otherwise to derive inferences (Yin 2014). Researchers typically rely on qualitative data analysis techniques. However, also quantitative data analysis can support case studies. Data analysis strategies include comparing the data to theoretical propositions and, thus, reflecting on theory and examining opposing explanations.

Sharing is the final step and includes identifying a target audience and presenting them the findings, typically in forms of theses or research articles. Also, the step includes a feedback loop. After the presentation, the audience, case study participants, and researchers can reflect on and confirm findings.

We fully applied the case study approach in our study "Practices for Open Business Model Innovation – An Innomediaries Perspective" (P7) (Weking et al. 2020a). The study "Business Model Innovation Strategies for Product Service Systems – An Explorative Study in the Manufacturing Industry" (P6) (Weking et al. 2018a) follows an explorative approach with fuzzy boundaries of cases. Hence, we were able to apply most of the guidelines for case study research. The studies "Archetypes for Industry 4.0 Business Model Innovations" (P3) (Weking et al. 2018c), "Leveraging Industry 4.0 – A Business Model Pattern Framework" (P4) (Weking et al. 2020b), and "The Impact of Blockchain Technology on Business Models – A Taxonomy and Archetypal Patterns" (P5) (Weking et al. 2019b) have a more confirmatory approach and use methods between multiple case studies and case surveys. Thus, we were able to apply some of the guidelines for multiple case studies.

3.2.4 Case Survey

To improve the generalizability of in-depth case studies about new business model patterns, business model innovations, and transformation paths, we used guidelines of case survey research in three of seven studies. Case surveys close the gap between quantitative, generalizable surveys with large samples and qualitative, in-depth case studies with a small number of cases (Larsson 1993). Typically, case surveys build on a large number of published case studies. They use robust coding schemes to quantize qualitative data and to apply quantitative methods on the case dataset. Thus, case surveys serve as meta-analyses of cases (Paré et al. 2015) and combine advantages of qualitative and quantitative methods (Larsson 1993).

Larsson (1993) suggests several steps for conducting case surveys. First, researchers should develop research questions. Questions need to be grounded in theory and specific enough to develop an effective coding scheme. Yin/Heald (1975) suggests that testing theory is more appropriate for case surveys than theory developing. Larsson (1993), however, proposes that the research questions can focus on theory testing, i.e., confirmatory questions, as well as on theory development, i.e., explorative questions. For theory development, the strength of case surveys is the discovery of complex patterns across a large number of cases.

Second, case selection criteria have to be defined and case studies have to be collected (Larsson 1993). To ensure reliability and generalizability, researchers need to determine the sampling strategy including clear inclusion and exclusion criteria. Research design, publication status, and analyzed time frame should be included as control variables and should not be part of the selection criteria. For the collection of case studies, researchers can start with cases that they are already familiar with. Further, a broad range of sources should be included, for example, journal and conference publications, dissertations, teaching cases, and business literature. Cases should be checked against the inclusion and exclusion criteria. Cases with too little information should be excluded.

Third, researchers have to design the coding scheme and conduct the coding (Larsson 1993). The coding scheme enables, documents, and governs the quantizing of the qualitative case data. For developing the coding scheme researchers need to agree on a reliable simple coding scheme or an information-rich complex one. Complex coding schemes with finer scales can capture more information. However, a high number of alternatives and distinctions also increases the risk of low interrater reliability. Simple coding schemes have typically fewer alternatives, for example, *yes* and *no* only, and, therefore higher interrater reliability. For actually conducting the case coding, two to three raters per case are needed.

Fourth, researchers can conduct statistical analyses with the coded data. However, before starting the analyses, they should clarify the coding and construct validity (Larsson/Finkelstein 1999). When validity is ensured, bivariate and multivariate statistics and structural equation modeling can be used (Larsson 1993).

In our studies "Archetypes for Industry 4.0 Business Model Innovations" (P3) (Weking et al. 2018c), "Leveraging Industry 4.0 – A Business Model Pattern Framework" (P4) (Weking et al. 2020b), and "The Impact of Blockchain Technology on Business Models – A Taxonomy and Archetypal Patterns" (P5) (Weking et al. 2019b), we partly applied the case survey method by combining it with guidelines from the multiple case study approach.

3.2.5 Quantitative Methods

To argument taxonomy and pattern development, evaluate taxonomies, and analyze the influence of applied business model patterns on firm performance, we additionally used two quantitative methods in three of seven studies.

First, for discovering structures in data, i.e., exploratory quantitative data analysis, we used cluster analysis (Backhaus et al. 2018). Cluster analyses aim to combine objects into groups (clusters) in such a way that the objects in the same group are as similar as possible and the groups are as dissimilar as possible. Cluster analysis describes a general task with various possible algorithms. In general, a cluster analysis needs three steps: determining how to measure the distance between objects (1), determining the merging algorithm (2), and determining the number of clusters (3). The most commonly used merging algorithm is hierarchical agglomerative clustering (Backhaus et al. 2018). The algorithm starts with a setting where each object constitutes its own cluster. Then clusters are iteratively merged until one large cluster remains. Methods to determine merging clusters are single-linkage, complete-linkage, average-linkage, centroid, median, and ward method (Kaufman/Rousseeuw 2009; Struyf et al. 1997). Afterward, researchers need to determine the optimal number of clusters and, therefore, select one intermediate state of the iterative algorithm as an optimal solution. To determine the number of clusters, several approaches exist, such as the elbow method (Backhaus et al. 2018), the McClain index (McClain/Rao 1975), the C-index (Hubert/Levin 1976), the silhouette index (Rousseeuw 1987), and the Dunn index (Dunn 1974).

In our study “A Hierarchical Taxonomy of Business Model Patterns” (P1) (Weking et al. 2018b), we used cluster analysis to categorize business model patterns from literature. Several intermediate solutions of the clustering serve as different hierarchical levels in the final hierarchical taxonomy. In our study “The Impact of Blockchain Technology on Business Models – A Taxonomy and Archetypal Patterns” (P5) (Weking et al. 2019b), we used cluster analysis to group firms concerning their business model characteristics. The final clusters constitute new business model patterns levering blockchain technology.

Second, for testing structures in data, i.e., confirmatory quantitative data analysis, we used contingency analyses with chi-squared tests (Backhaus et al. 2018) and Fisher’s exact test (Fisher/Bennett 1990). Cross tabulations and contingency analysis uncover relationships between nominally scaled variables. Cross tabulations can present the results of an inquiry in tabular form, which can indicate a possible relationship. When researchers assume a correlation, they can use a contingency analysis to investigate whether the relationship happened randomly in the sample or whether it is based on a systematic correlation. A chi-square test is a common approach for testing this. For samples with sizes smaller than 20 or with skewed distributions, the literature recommends the use of Fisher’s exact test (Fisher/Bennett 1990). Afterward, it can be tested how strong this correlation is with the phi-coefficient.

In our study “Does Business Model Matter for Startup Success? A Quantitative Analysis” (P2) (Weking et al. 2019a), we use the contingency analysis, the chi-square test, and Fisher’s exact test to analyze and proof that applied business models in startups correlate with their survival rate.

Part B

4 A Hierarchical Taxonomy of Business Model Patterns (P1)[1]

Title	A Hierarchical Taxonomy of Business Model Patterns
Authors	Weking, Jörg* (joerg.weking@tum.de) Hein, Andreas* (andreas.hein@tum.de) Böhm, Markus* (markus.boehm@tum.de) Krcmar, Helmut* (krcmar@in.tum.de) * Technische Universität München, Chair for Information Systems, Boltzmannstraße 3, 85748 Garching, Germany
Publication	Electronic Markets (2018, in press, DOI: 10.1007/s12525-018-0322-5)
Status	Published
Contribution of first author	Problem definition, research design, literature search and analysis, interpretation, reporting

Table 5. Fact Sheet Publication P1

Abstract

Although business model innovation (BMI) is essential to remaining competitive, many firms fail at it. A promising approach is building on reoccurring successful solutions – business model patterns (BMP) – as a blueprint for BMI. However, existing patterns face constraints subject to a high diversity and overlaps among patterns. In addition, literature do not consider relations among BMPs, which limits their potential for BMI. This paper develops a hierarchical taxonomy of BMPs including generalizations and specializations based on inheritance. We conduct a literature review to identify patterns and a cluster analysis to create an inductive structure, followed by a qualitative analysis. The resulting hierarchical taxonomy includes 194 elements. It is the first hierarchical taxonomy of BMPs. The hierarchy addresses the diversity of patterns and overlaps with inheritance. It aids research to structure and understand BMPs. For practice, the taxonomy allows for the application of patterns and supports BMI.

Keywords: Business model, Business model pattern, Taxonomy, Hierarchical structure, Cluster analysis.

5 Does Business Model Matter for Startup Success? A Quantitative Analysis (P2)

Title	Does Business Model Matter for Startup Success? A Quantitative Analysis
Authors	Weking, Jörg* (joerg.weking@tum.de) Böttcher, Timo* (timo.boettcher@tum.de) Hermes, Sebastian* (sebastian.hermes@tum.de) Hein, Andreas* (andreas.hein@tum.de) * Technische Universität München, Chair for Information Systems, Boltzmannstraße 3, 85748 Garching, Germany
Publication	European Conference on Information Systems (ECIS), 2019
Status	Published
Contribution of first author	Problem definition, research design, data collection and analysis, interpretation, reporting

Table 6. Fact Sheet Publication P2

Abstract

In multiple research areas, scholars try to find determinants for business performance. Especially for entrepreneurship, this is of interest as failure rates are high. Qualitative research demonstrates that a firm's business model influences its performance. However, research lacks large-scale quantitative studies to analyze if a firm's applied business model explains heterogeneity in business performance. Therefore, this research builds on a dataset of 500 startups and analyzes the relationship of their applied business model patterns and their business performance (i.e., survival as proxy). Two business model patterns are significantly correlated with a higher survival rate (i.e., Freemium and Subscription), while four patterns are significantly correlated with a lower survival rate (i.e., Cross Selling, Hidden Revenue, Layer Player, and No Frills). For literature, we enrich qualitative research with statistical evidence that business models matter for business performance and strengthen the concept's role as a useful theoretical construct in management and entrepreneurship research. For practice, the paper reinforces the importance of business models for startup success and provides clear guidance regarding which business model pattern increases the probability of startup survival. Findings provide first insights in the relationship of business models and business performance and opens up fruitful areas for future research.

Keywords: Business Model, Startup, Performance, Quantitative Research.

6 Archetypes for Industry 4.0 Business Model Innovations (P3)

Title	Archetypes for Industry 4.0 Business Model Innovations
Authors	Weking, Jörg* (joerg.weking@tum.de) Stöcker, Maria* (maria.stoecker@tum.de) Kowalkiewicz, Marek[+] (marek.kowalkiewicz@qut.edu.au) Böhm, Markus* (markus.boehm@tum.de) Krcmar, Helmut* (krcmar@in.tum.de) * Technische Universität München, Chair for Information Systems, Boltzmannstraße 3, 85748 Garching, Germany [+] Queensland University of Technology, Chair in Digital Economy, 2 George St, Brisbane City QLD 4000, Australia
Publication	Americas Conference on Information Systems (AMCIS), 2018
Status	Published
Contribution of first author	Problem definition, research design, data collection and analysis, interpretation, reporting

Table 7. Fact Sheet Publication P3

Abstract

Industry 4.0 (I4.0) also known as the fourth industrial revolution has emerged for describing the digitalization of manufacturing industries. In practice, the transition to I4.0 is crucial for manufacturing firms to sustain competitive advantage and seize new opportunities. Most research focuses on the technological aspects of I4.0 in form of product and process innovations. Despite I4.0's rising attention among both researchers and practitioners, there exists only little research about I4.0 business model innovation (BMI), even though business model (BM) innovators can be more successful than product or process innovators. To address this research gap, we analyze 15 case studies of I4.0 BM innovators. We develop a taxonomy to characterize I4.0 BMs and derive 13 archetypes of I4.0 BMIs that describe transitions towards I4.0 BMs. The three identified super-archetypes are integration, servitization and expertise as a service. Our study deepens the understanding and structure of I4.0 BMs and I4.0 BMIs.

Keywords: Business model innovation, Industry 4.0, Industrie 4.0, Taxonomy, Archetypes, Case study.

7 Leveraging Industry 4.0 – A Business Model Pattern Framework (P4)[2]

Title	Leveraging Industry 4.0 – A Business Model Pattern Framework
Authors	Weking, Jörg* (joerg.weking@tum.de) Stöcker, Maria* (maria.stoecker@tum.de) Kowalkiewicz, Marek[+] (marek.kowalkiewicz@qut.edu.au) Böhm, Markus* (markus.boehm@tum.de) Krcmar, Helmut* (krcmar@in.tum.de) * Technische Universität München, Chair for Information Systems, Boltzmannstraße 3, 85748 Garching, Germany [+] Queensland University of Technology, Chair in Digital Economy, 2 George St, Brisbane City QLD 4000, Australia
Publication	International Journal of Production Economics (2020, Vol. 225, p. 107588, DOI: 10.1016/j.ijpe.2019.107588)
Status	Published
Contribution of first author	Problem definition, research design, data collection and analysis, interpretation, reporting

Table 8. Fact Sheet Publication P4

Abstract

Industry 4.0 (I4.0), also known as the fourth industrial revolution, describes the digitalization of manufacturing industries. The transition to I4.0 is crucial for manufacturing firms to sustain competitive advantage and seize new opportunities. Most research has focused on the technological aspects of I4.0 in the form of product and process innovations. Despite I4.0's rising attention from both researchers and practitioners, little research exists about I4.0 business model (BM) innovation, even though BM innovations can be more successful than product or process innovations. To address this research gap, we analyze 32 case studies of I4.0 BM innovators. We develop a taxonomy to characterize I4.0 BMs and derive 13 patterns of I4.0 BMs by applying the taxonomy to the case studies. Three super-patterns are identified: integration, servitization, and expertization. Integration innovates a BM with new processes and integrates parts of the supply chain. New combined products and services are the basis for servitization.

Expertization is a hybrid of product- and process-focused BMs, which includes consulting services and multi-sided platforms. This study contributes to research with a framework for describing, analyzing, and classifying BMs for I4.0. The findings deepen the understanding of how I4.0 impacts ecosystem roles, BMs, and service systems. Archetypal patterns show how firms can leverage I4.0 concepts and build a conceptual basis for future research. The taxonomy supports practitioners in evaluating the I4.0-readiness of their existing BM. The patterns additionally illustrate opportunities for becoming an I4.0 firm.

Keywords: Business model, Industry 4.0, Taxonomy, Patterns, Case study, Internet of things (IoT).

8 The Impact of Blockchain Technology on Business Models – A Taxonomy and Archetypal Patterns (P5)[3]

Title	The Impact of Blockchain Technology on Business Models – A Taxonomy and Archetypal Patterns
Authors	Weking, Jörg* (joerg.weking@tum.de) Mandalenakis, Michael* (michael.mandalenakis@tum.de) Hein, Andreas* (andreas.hein@tum.de) Hermes, Sebastian* (sebastian.hermes@tum.de) Böhm, Markus* (markus.boehm@tum.de) Krcmar, Helmut* (krcmar@in.tum.de) * Technische Universität München, Chair for Information Systems, Boltzmannstraße 3, 85748 Garching, Germany
Publication	Electronic Markets (2019, in press, DOI: 10.1007/s12525-019-00386-3)
Status	Published
Contribution of first author	Problem definition, research design, data collection and analysis, interpretation, reporting

Table 9. Fact Sheet Publication P5

Abstract

Blockchain technology enables new ways of organizing economic activities, reduces costs and time associated with intermediaries, and strengthens the trust in an ecosystem of actors. The impact of this seminal technology is reflected by an upcoming research stream and various firms that examine the potential uses of blockchain technology. While there are promising use cases of this new technology, research and practice are still in their infancy about altering existing and creating new business models. We develop a taxonomy of blockchain business models based on 99 blockchain ventures to explore the impact of blockchain technology on business models. As a result, we identify five archetypal patterns, which enhance our understanding of how blockchain technology affects existing and creates new business models. We propose to use these results to discover further patterns fueled by blockchain technology and illustrate how firms can use blockchain technology to innovate their business models.

Keywords: Blockchain, Business model, Design science, Taxonomy, Pattern, Platform.

9 Business Model Innovation Strategies for Product Service Systems – An Explorative Study in the Manufacturing Industry (P6)

Title	Business Model Innovation Strategies for Product Service Systems – An Explorative Study in the Manufacturing Industry
Authors	Weking, Jörg* (joerg.weking@tum.de) Brosig, Christoph* (christoph.brosig@tum.de) Böhm, Markus* (markus.boehm@tum.de) Hein, Andreas* (andreas.hein@tum.de) Krcmar, Helmut* (krcmar@in.tum.de) * Technische Universität München, Chair for Information Systems, Boltzmannstraße 3, 85748 Garching, Germany
Publication	European Conference on Information Systems (ECIS), 2018
Status	Published
Contribution of first author	Problem definition, research design, data analysis, interpretation, reporting

Table 10. Fact Sheet Publication P6

Abstract

In saturated, product-oriented markets, services provide the potential for differentiation and growth. Innovating a firm's business model (BM) by adopting product service systems (PSSs) seems promising. However, research provides only limited insights on how manufacturing firms can innovate their BM towards offering PSSs. Literature lacks strategies not only to adopt PSSs, but also to further innovate existing PSS BMs. Therefore, this study analyzes reoccurring PSS BM patterns as well as innovation strategies to transform from one pattern to another. We use an explorative, qualitative study with interviews in 14 business units of large manufacturing corporations that are engaged in a PSS BM innovation initiative. Results show three PSS BM patterns, i.e. product-oriented manufacturing, use-oriented enabling and result-oriented service offering. We demonstrate their practical implementation and further derive a conceptual framework for PSS BM innovation describing six evolutionary or transformative innovation strategies. Evolutions, i.e. universalization, digitization and service expansion, change only modules of a BM, whereas transformations, i.e. servitization, integration and leap-frogging, affect the whole architecture. Limitations are the small number of interviews and related limited number of cases. Nevertheless, findings indicate transformation paths and extensions to existing research on PSS types regarding the customization and ownership of PSSs.

Keywords: Product Service Systems, Business Model Innovation, Innovation Strategies, Qualitative Study

10 Practices for Open Business Model Innovation – An Innomediaries Perspective (P7)

Title	Practices for Open Business Model Innovation – An Innomediaries Perspective
Authors	Weking, Jörg* (joerg.weking@tum.de) Lupberger, Janes* (janes.lupberger@tum.de) Hermes, Sebastian* (sebastian.hermes@tum.de) Hein, Andreas* (andreas.hein@tum.de) Böhm, Markus* (markus.boehm@tum.de) Krcmar, Helmut* (krcmar@in.tum.de) * Technische Universität München, Chair for Information Systems, Boltzmannstraße 3, 85748 Garching, Germany
Publication	Internationale Tagung Wirtschaftsinformatik (WI)
Status	Published
Contribution of first author	Problem definition, research design, data collection and analysis, interpretation, reporting

Table 11. Fact Sheet Publication P7

Abstract

Innovative business models generate competitive advantage and are becoming more important than innovative products or processes. Despite its importance, firms continuously fail to innovate business models. Reasons are inhibiting structures, cultures and missing resources or capabilities. Integrating external stakeholders can help to overcome these barriers. Turning to innovation intermediaries, so-called “Innomediaries” support firms. Innomediaries specialize on the integration of suppliers, customers, or inventive partners (startups or universities) into innovation projects. With three in-depth case studies, we provide an actionable framework for integrating external stakeholders into business model innovation. It guides firms when, with whom, and how they can integrate external stakeholders to reduce risks and accelerate the creation of innovations. We shed light on the understudied intersection of open innovation and business model innovations and the linking role of innomediaries. Future research can extend the role of IT, protection against opportunistic behavior, and innomediaries as service platforms in innovation ecosystems.

Keywords: Business Model, Open Innovation, Innovation Intermediary, Case Study.

Part C

11 Summary of Results

To address the three research questions of this thesis, we used seven publications. We summarize the findings of the three research questions in the following by describing how each of the publications addresses a particular issue of a research question. The subsequent section discusses these results.

RQ1: *How can firms leverage business model patterns for business model innovations?*

Hierarchical Taxonomy of Business Model Patterns. Based on a literature review and the iterative taxonomy development method, we identified a set of 194 business model patterns and arranged them in a hierarchical structure (P1). This hierarchical taxonomy covers inheritance with generalizations and specializations similar to a class diagram. The taxonomy has eight elements on its highest level: two holistic business model patterns (i.e., multi-sided market and merchant model) and six main elements of business models (i.e., customer group, revenue stream, payment/ pricing model, value proposition, value network, and value proposition development). The taxonomy structures the various business model patterns and, thus, resolves issues concerning overlaps and diversity in abstraction levels and coverage. It reduces complexity and enables firms to apply business model patterns and leverage them for business model innovations.

Influence of Business Model Patterns on Start-Up Success. Based on a contingency analysis, chi-square test, and Fisher's exact test with 500 startups, we identified business model patterns that correlate with higher or lower survival rates and show that the business model matters for startup success (P2). The business model patterns Freemium and Subscription significantly correlate with a higher survival rate, whereas Layer Player, Cross Selling, Hidden Revenue, and No Frills significantly correlate with a lower survival rate. Subscription describes business models where "the customer pays a regular fee, typically on a monthly or an annual basis, in order to gain access to a product or service" (Weking et al. 2019a). With a Freemium business model, "the basic version of an offering is given away for free in the hope of eventually persuading the customers to pay for the premium version." (Weking et al. 2019a).

RQ2: *Which business model patterns emerge when incumbent firms innovate their business model?*

Business Model Taxonomy and Archetypal Patterns for Industry 4.0. Based on our literature review and the hierarchical taxonomy of business model patters (P1), we used several exploratory case studies and case surveys in different IT-enabled contexts (P3 – P5). P3 and P4 focus on Industry 4.0. Based on 32 cases that leverage Industry 4.0, we developed a business model taxonomy and 13 archetypal business model patterns. The 13 patterns include three super-patterns, i.e., Integration, Servitization, and Expertization, and ten detailed sub-patterns. Integration covers firms that integrate external parts of the supply chain. In Servitization, firms offer integrated products and services. Expertization comprises firms that offer consulting services or multi-sided platforms.

Business Model Taxonomy and Archetypal Patterns for Blockchain Technology. Building on our literature review and the hierarchical taxonomy of business model patters (P1), we used a further case survey to develop a business model taxonomy and five archetypal patterns for blockchain business models (P5). The patterns are: First, Blockchain for Business Integration (i.e., “provision of a standardized shared database to improve interoperability among users”), second, Blockchain as Multi-sided Platform (i.e., “provision of a marketplace without regulating intermediaries”), third, Blockchain for Security (i.e., “reinforcement of security aspects by using several aspects of the blockchain technology”), fourth, Blockchain Technology as Offering (i.e., “provision of blockchain-APIs [application programming interfaces]”), and fifth, Blockchain for Monetary Value Transfer (i.e., “enablement of direct value transfer among peers”) (Weking et al. 2019b).

RQ3: *What are transformation paths in business model innovations of incumbent firms?*

Transformation Paths for Business Model Innovations towards Product-Service Systems. To answer the third research question, we rely on exploratory interviews (P6). Based on 14 interviews, we identified six business model innovation strategies for product-service systems, which serve as transformation paths. Three transformation paths influence the whole business model architecture, i.e., Servitization, Integration, and Leap-frogging, whereas three paths change business model modules only, i.e., Universalization, Digitization, and Service Expansion.

Practices for Open Business Model Innovation. In a further multiple case study (P7), we analyzed innovation intermediaries, i.e., innomediaries, to understand how they support incumbents in business model innovations by integrating external stakeholders. The main finding is an actionable process framework that guides firms to integrate whom, how, and when in open business model innovation. Customers can be integrated as early as possible with passive (e.g., netnography), reactive (e.g., surveys), and active integration methods (e.g., focus groups). Experts, customers, startups, and scholars with a variety of backgrounds and perspectives improve the effectiveness of ideation workshops. Potential partners can be integrated after selecting an idea to closely develop prototypes and the final business model.

Table 12 gives an overview of the key findings of this thesis.

P	RQ	Findings
P1	RQ1	▪ Extant literature covers 184 business model patterns. ▪ Business model patterns are hard to use and apply since they show a high diversity in their degree of coverage and level of abstraction, which leads to strong overlaps between patterns. ▪ A hierarchical taxonomy of business model patterns where subordinate patterns inherit characteristics from superordinate patterns can structure and, thus, support applying patterns. ▪ The hierarchical taxonomy identifies two overarching holistic business model patterns: (1) Merchant Model and (2) Multi-sided Platform. ▪ The hierarchical taxonomy identifies six common business model elements: (1) Customer Group, (2) Payment/ Pricing Model, (3) Revenue Stream, (4) Value Network, (5) Value Proposition, and (6) Value Proposition Development.
P2	RQ1	▪ Some business model patterns correlate with a higher startup survival rate, while others correlate with lower startup survival rates. ▪ The business model patterns Freemium and Subscription significantly correlate with a higher survival rate. ▪ A Freemium business model is used when "the basic version of an offering is given away for free in the hope of eventually persuading the customers to pay for the premium version." (Weking et al. 2019a). ▪ In Subscription business models, "the customer pays a regular fee, typically on a monthly or an annual basis, in order to gain access to a product or service" (Weking et al. 2019a). ▪ Layer Player, Cross Selling, Hidden Revenue, and No Frills significantly correlate with a lower survival rate.
P3	RQ2	▪ In an initial study with 15 cases, we developed a business model taxonomy for Industry 4.0. ▪ Industry 4.0 business models can be structured in 13 business model patterns. ▪ There are three superior business model patterns for Industry 4.0: (1) Integration, (2) Servitization, and (3) Expertise as a Service. ▪ Integration covers the subordinate patterns (1) Crowdsourced Innovation, (2) Production as a Service, and (3) Mass Customization. ▪ Servitization includes the subordinate patterns (1) Life-long Partnerships, (2) Product as a Service, and (3) Result as a Service. ▪ Expertise as a Service comprises the subordinate patterns (1) Product-related Consulting, (2) Process-related Consulting, (3) Broker Platforms, and (4) IoT Platforms.
P4	RQ2	▪ In a subsequent study with 32 cases, we developed a revised taxonomy for Industry 4.0 business models. ▪ Industry 4.0 business models comprise 13 revised business model patterns. ▪ The three revised superior business model patterns for Industry 4.0 are (1) Integration, (2) Servitization, and (3) Expertization. ▪ Expertization comprises the revised subordinate patterns (1) Product-related Consulting, (2) Process-related Consulting, (3) Product-related Platformization, and (4) Process-related Platformization. ▪ Remaining subordinate patterns did not change.
P5	RQ2	▪ A taxonomy for blockchain business models based on 99 cases. ▪ There are five patterns of blockchain business models: (1) Blockchain for Business Integration, (2) Blockchain as Multi-sided Platform, (3) Blockchain for Security, (4) Blockchain Technology as Offering, (5) Blockchain for Monetary Value Transfer.
P6	RQ3	▪ In an initial exploratory study with 14 interviews, we identified six business model innovation strategies, i.e., transformation paths, for product-service systems. ▪ Three of them evolutionary: (1) Universalization, (2) Digitization, and (3) Service Expansion. ▪ Three of them transformative: (1) Servitization, (2) Integration, and (3) Leap-frogging. ▪ Use-oriented product-service systems do not exclude an ownership transfer.
P7	RQ3	▪ To support business model innovation, firms increasingly rely on external partners. ▪ A framework for open business model innovation guiding firms when to integrate whom and how. ▪ Innovation intermediaries, i.e., innomediaries, as experts in external stakeholder integration integrate customers early, invite a variety of stakeholders for ideation, and approach development partners right after idea selection.

Table 12. Overview of Key Results

12 Discussion

Based on the summary of our results, we discuss findings against the background of the related body of knowledge. First, we discuss how our results support that business models go beyond traditional strategy theories by challenging their assumptions. Second, we discuss how our work contributes towards a language of business model patterns. Third, we discuss the findings on how advancements in IT change business models and innovation processes.

12.1 Challenging Assumptions of Traditional Strategy Theories

In their literature review, Massa et al. (2017) show that business model research can challenge some assumptions of traditional strategy theories, i.e., the positioning and resource-based view. Our results show strong support for these arguments. Table 13 gives an overview of challenged assumptions of traditional strategy theories, which we discuss in the following.

Traditional Assumption	Challenge	Example Business Model Patterns
Firms and customers have perfect information.	Some business models create value by reducing information asymmetries.	Online auctions or e-malls use rating systems to reduce information asymmetries about products (P1). The pattern value chain integrator reduces information asymmetries within a supply chain (P1).
Firms and their customers have unlimited cognitive abilities.	Some business models capture value by exploiting the limited cognitive abilities of customers.	Examples are rent instead of buy (P1) or product as a service (P3 and P4). With unlimited cognitive abilities, customers would calculate the correct net present value of a product and, thus, might prefer to buy it.
No externalities.	Some business models create value for third parties with transactions between a focal firm and a customer.	Multi-sided platform patterns (P1), Platformization patterns (P4), and Blockchain as Multi-sided Platform (P5) leverage network effects.
Competitive advantage is single-sourced and supply-side only.	Some business models build their competitive advantage on both, the system of activities (positioning) and resources (RBV) drawing from both, demand side and supply side.	Platforms where customers utilize and contribute content, i.e., crowdsourcing platforms, such as Open Source communities (P1) or Crowdsourced Innovation (P4).

Table 13. Challenged Assumptions of Traditional Strategy Theories (based on Massa et al. 2017)

First, by building on information asymmetries, business models challenge the assumption that firms and customers have perfect information (Massa et al. 2017). When applying the business model patterns Online Auction or E-mall, often a crowd-based rating system is used to reduce information asymmetries between sellers and customers (P1). The business model pattern Value Chain Integrator describes how firms can gather, combine, and distribute information across a value network. In this way, the business model's purpose is to reduce information asymmetries within a network. The business model used as a unit of analysis allows for analyzing situations with imperfect information.

Second, by exploiting limited cognitive abilities, business models challenge the assumption of traditional strategy theories that firms and their customers have unlimited cognitive abilities (Massa et al. 2017). Examples are the business model patterns Rent instead of Buy (P1) or Product as a Service (P3 and P4). If both parties would have unlimited cognitive capabilities, customers could calculate a perfectly correct net present value and might prefer buying a product instead of renting it. However, we found several cases where Product as a Service is worthwhile for providers (P3 and P4). Thus, building on the business model as a unit of analysis, we can analyze states that contain parties with limited cognitive abilities.

Third, business models challenge the assumption that a transaction between a firm and a customer does not show benefits or costs for third parties (Massa et al. 2017). Platform business models, for example, heavily rely on network effects. Our hierarchical taxonomy of business model patterns reveals 24 patterns that all incorporate a network of third parties and/ or customers (P1). Also in the contexts of Industry 4.0 and blockchain, we found various cases and patterns that leverage network effects with platform business models (P3 – P5). The business model used as a unit of analysis enables us to investigate externalities.

Fourth, while traditional theories focus on the supply side of value *capture*, business models focus on value *creation* in the supply side and demand side, because a business model is nested between a firm and its ecosystem (Massa et al. 2017). Also here, we can see that platform business models challenge this assumption. In particular, platforms where customers co-create value. Examples are the business model patterns Open Source Community (P1) and Crowdsourced Innovation (P4). By using the business model as a unit of analysis we can analyze the value creation in both the supply and demand side.

Summarizing, with the business model as a unit of analysis, we can go beyond traditional strategy theories by challenging their assumptions. With business models and business model patterns, we can analyze situations with imperfect information, ecosystems containing parties with limited cognitive abilities, externalities, and value creation on the supply and demand side. Business models as a unit of analysis decouple value creation and value capture and focus on value creation. The decoupling is especially useful for internet companies, where customers expect basic functions to be free (Teece 2010). We show that even in best-performing business model patterns value capture is not linked to value creation, i.e. Freemium and Subscription (P2). Business model patterns allow for capturing more than traditional strategy theories. Hence, the business model is a valid unit of analysis.

12.2 Business Model Taxonomies and Patterns as Language

The developed business model taxonomies and business model patterns in this thesis go beyond extant business model frameworks (e.g. Osterwalder/Pigneur 2010; Gassmann et al. 2014) and represent a language for business models (Alexander 1977). Similar to Alexander (1977) in an architectural context, we see taxonomies and patterns as a language that describes problems and their solutions in a business context. Some business problems occur again and again. The language of business model taxonomies and patterns describes a solution for these problems. The pattern language supports describing, classifying, and analyzing business models in specific IT-enabled contexts.

First, taxonomies and patterns can serve as a tool for describing. Business model patterns bundle similar characteristics of real-world cases. Examples are Result as a Service in the Industry 4.0 context and Blockchain as Multi-sided Platform (P3 and P4). These patterns can then be used to describe a firm's current or future business model. With related cases, the patterns provide richer and more information than a plain business model framework. Further, the hierarchical business model taxonomy can be used to describe business models that build on more than one pattern (P1). The hierarchical taxonomy enables us to describe different perspectives of a business model.

Second, the business model taxonomies and patters can be used as a language for classifying. Taxonomies and patterns from different contexts (P1, P3, P4, and P5) can be used to characterize and differentiate enterprises based on the business model (Täuscher/Laudien 2018). The findings underline and demonstrate that a business model is a useful unit of analysis.

Third, developed business model taxonomies and patterns can be a useful language for analyzing a firm’s business models and future prospects. Taxonomies and patterns can support the analysis of business models in general (P1), in the context of Industry 4.0 (P3, P4), and in the context of blockchain technologies (P5) by comparing characteristics with characteristics in taxonomies and related underlying cases. Further, opportunities for business model innovations can be derived by considering related business model patterns.

Taxonomies and patterns can further serve as an initial step for theorizing business models (Doty/Glick 1994; Rich 1992). Construct clarity is fundamental for empirical studies and communicating research (Suddaby 2010). It further supports creativity (Suddaby 2010). Taxonomies and patterns can help to describe and classify a business model and, thus, supports definition clear constructs as a step towards theory building.

12.3 How Advances in IT Change Business Models and Innovation Processes

Our research shows that business models (P1-P5), and business model transformation paths (P6) and innovation processes (P7) undergo a change, which is heavily supported by advances in IT.

First, business model patterns change. Traditional business model patterns, such as the Merchant Model (P1), have been digitalized (Rappa 2001). Other patterns have been there for a long time. However, now they have gained momentum and propagate rapidly, such as multi-sided platforms (P1, P3 – P5) (Parker et al. 2017; Osterwalder/Pigneur 2010). Our empirical work in IT-driven domains underlines these trends. In the context of Industry 4.0 and product-service systems (P3, P4, and P6), we see that automation and product and process innovations are not enough (Gassmann et al. 2014). Manufacturing firms conduct business model innovations towards more service offerings and platform business models. Advances in IT enable manufacturers to offer more innovative revenue models, such as usage-based or result-based payments based on IoT sensors. 3D printing enables further services, such as offering Production as a Service (P3 and P4). Some manufacturers even offer consulting services on how firms can digitally transform (P3 and P4). Furthermore, blockchain, as a new advance in IT, enables several new business models. Similarly, there is a trend towards platform business models in the blockchain context (P5). The most common blockchain business model is a multi-sided platform: a marketplace without intermediaries. These trends also lead to more strongly intertwined ecosystems. We can see that in the trend towards platforms (P1, P3 – P5) and the contexts of Industry 4.0 (P3 and P4) and blockchain (P5). In Industry 4.0, all identified business model patterns strengthen the integration of value network partners, such as customers, suppliers, or complementors (P3 and P4). The blockchain technology itself serves as a distributed network that is capable of integrating different actors. In this way, blockchain directly contributes to more intertwined ecosystems. Example business model patterns are blockchain for business integration, for multi-sided platforms, or for value transfer.

Second, digital business model innovations change how firms adapt their strategy. New transformation paths and business model innovation processes emerge. While new business models imply new transformation paths, the way how firms approach these paths is changing. Advancements in IT enable manufacturers to innovate more revolutionary (P6). They can innovate more quickly and skip preliminary states that were necessary in the past. Examples are manufacturers that innovate from product sales directly to results-oriented service offerings by building on IoT technology (P6). Moreover, experimentation is getting more important than rigorous planning. There is a trend towards more experimentation in business model innovation (Chesbrough/Rosenbloom 2002; Massa et al. 2017; Sosna et al. 2010). Business model innovation is not about a fully understood and carefully calculated plan of actions, but about gathering and incorporating new information and opportunities with continuous changes. New business models are seen as hypotheses that require continuous adaption. Even in rather traditional industries, such as manufacturing (P3 and P4), business model innovations do not result from positioning in a market or managing resources, but firms experiment with completely new ways of doing business (McGrath 2010). To accomplish these new processes, firms increasingly integrate external stakeholders and new external partners, such as innomediaries, startups, universities, and other external experts (P7).

13 Limitations

The studies embedded in this work and, as a result, the results of the entire work are subject to several limitations. Although, the mixed-method research strategy of this thesis mitigates some limitations, limitations arise from the research approaches we pursued, from the data sources we chose, and from our defined scope for this work. While each publication covers a detailed discussion of their limitations, we will now elaborate on some general shortcomings of the research approaches.

The main limitation of **literature reviews** is that they depend on the search process and its identified papers. Even when relying on forward and backward search (Webster/Watson 2002), the search process might not grasp every single paper that is relevant for the topic. The many different interpretations of business models reinforce this issue (Massa et al. 2017). To mitigate this limitation, this thesis builds on several high-published literature reviews on business models and business model innovation (Massa et al. 2017; Zott et al. 2011; Foss/Saebi 2017; Spieth/Schneider 2016). Moreover, since the review process of scientific literature often takes years, we included secondary literature for our case surveys to ensure currency (P3, P4, and P5). Second, the analysis of literature reviews is prone to coding biases. For example, in our literature review about business model patterns (P1), the coding depends on the researchers' interpretations of the business model patterns definitions. To mitigate this issue, we built on two coders in P1.

The iterative **taxonomy development** method likewise comes with limitations. First of all, taxonomies cannot be correct or perfect (Nickerson et al. 2013). Problems to analyze are typically under change and aiming at perfect taxonomies would be a moving target. We can see this issue in all taxonomies of this thesis (P1, P3, P4, and P5). The hierarchical taxonomy of business model patterns (P1) covers business model patterns from the literature only and does not cover additional patterns that are not published yet. Likewise, Industry 4.0 and blockchain are under constant change. Hence, the developed taxonomies cover a snapshot of the current situation (P3, P4, and P5). However, taxonomies should not be perfect, but useful (Nickerson et al. 2013). The developed taxonomies are extendable and, thus, serve as a good basis for characterizing future business model patterns. Moreover, the taxonomies that are based on a case survey (P3, P4, and P5) come with additional limitations, which we discuss below.

Two publications of this thesis are based on **case studies** (P6 and P7). In addition to the various benefits of case studies, e.g., rich in-depth information about one particular phenomenon, they reveal some limitations. First, case studies are not statistically generalizable. We study 14 (P6) respectively three cases (P7), which is not sufficient for quantitative methods. Further, both of our studies, for example, analyze German firms. Germany shows a specific type of culture that might impact the behavior of firms concerning business model innovations (Hofstede 1984). Second, we conducted interviews, which we used as primary data. Interviews can include and raise some biases. In interviews, the researcher is the main tool for data collection. When conducting interviews, researchers depend on their abilities and instincts. Moreover, interview partners can introduce biases. The retrospective sensemaking bias, for example, covers "knee-jerk" reactions, which can blur findings (Eisenhardt/Graebner 2007). To mitigate this limitation, we used several interview partners in P7 and real-time cases in P6 and P7 (Eisenhardt/Graebner 2007).

The **case survey method**, which we used in three publications (P3, P4, and P5), comes with some limitations and biases depending on its underlying data, its literature review and applied analysis methods. First, the issue of possible biased results because of the search process of literature reviews is also applicable for case surveys (see the paragraph about literature reviews). Second, the given information quality can bias results. No data analysis technique can fix sparse or ambiguous case information. However, we used data triangulation with secondary data to mitigate this issue. Third, there can be a selection bias in cases because of the inclusion and exclusion criteria. If, for example, primary and secondary data of a case did not present sufficient information, we excluded the case. Fourth, case surveys come with publication bias. Only published cases can be included in the study, which might lead to a case sample with significant results only. It further reduces the overall number of cases. As a result, it is uncertain if the final case sample is representative. To mitigate this limitation, we enriched cases from literature with secondary data and also included cases from secondary data only. Here, we paid special attention to data triangulation. Fifth, underlying case studies typically focus on one specific phenomenon (Yin 2014). Since the case study method concentrates on the accumulation of knowledge, the unique aspects of individual cases may not be sufficiently considered (Yin/Heald 1975). However, this issue is valid for all review methods and in-depth unique results of one case are not the goal of a case survey.

In three publications of this thesis (P1, P2, and P5) we additionally build on **quantitative methods**, i.e., cluster analysis (P1) and contingency analysis (P2 and P5), which likewise come with limitations. In two publications (P1 and P5), we use categorical variables with crisp sets to describe business models. Hence, no qualitative data is included and some information about business models or cases is lost by coding the data. To cope with this challenge, we enriched the quantitative findings with a qualitative iteration in P1 and qualitatively evaluated the clusters in P5. Contingency analysis is used in P2 and P5. Both studies are likewise based on categorical variables, which perfectly suit case surveys (P5). Ration scaled variables would be the basis for profound econometric analyses of relationships between applied business models and firm performance (P2).

Also, the **topic of business model innovation** itself comes with limitations. We analyzed the early phases of business models in the contexts of Industry 4.0 (P3 and P4), blockchain technology (P5), and product-service systems (P6). The long-term performance of some of these business models is unknown. Similarly, we cannot make sure that analyzed business models do not change in the future. We analyzed a certain point of time only and business models typically change over time. Thus, we cannot be sure that the proposed taxonomies and patterns still work in the future. However, they are a good basis for extensions and further developments of business models.

14 Implications

The mixed-method approach of this thesis allows for addressing exploratory as well as confirmatory research questions (Venkatesh et al. 2013). This enables the findings of this thesis to provide rich implications for theory and practice.

14.1 Implications for Theory

Our findings contribute to four literature streams on business models, which are rooted in information systems and strategy literature. First, we contribute to the literature on **business models** in general. Findings enhance our understanding on how advancements in IT change business models or drive new business models (P3 – P6) and contribute to research on the business value of IT (Kohli/Grover 2008; Schryen 2010) and digital transformation (Matt et al. 2015; Riasanow et al. 2019). While extant research addresses technological implications (Kiel et al. 2016; Burmeister et al. 2016), we see how Industry 4.0 drives business models that are new to the manufacturing industry, such as highly individualized production, result-based service systems, consulting, or platform business models (P3 and P4). Blockchain technology likewise drives entirely new business models, such as multi-sided platforms without an intermediary (P5). We additionally find IT as an enabler for service-oriented business models in manufacturing (P6). Advancements in IT can support closer customer relationships and, thus, affect both, the products and services offered and the value creation and capture network (Massa et al. 2017). Hence, this thesis investigates how new technologies affect traditional business models and how to cope with these challenges, which is still an understudied topic in research (Johnson et al. 2008; Bock/Wiener 2017). Further calls for research are addressed by investigating how traditional industries digitally transform (Matt et al. 2015).

Second, findings contribute to the literature on **business model patterns, taxonomies,** and the rising research area of **enterprise classifications** grounded in business models (Täuscher/Laudien 2018) in different ways. The hierarchical business model pattern taxonomy (P1) structures the field and is, to the best of our knowledge, the first taxonomy on business model patterns that takes relations between them into account. These relations in terms of an inheritance structure enable illustrating and displaying the diversity of patterns in terms of degrees of coverage, hierarchical levels, and overlaps. Contrary to extant frameworks (Osterwalder/Pigneur 2010; Gassmann et al. 2014; Remané et al. 2017b; Taran et al. 2016), the taxonomy allows for putting patterns in relation to other patterns with higher and lower levels of abstraction. Moreover, findings generate new business model taxonomies and patterns in different contexts (P3 – P6), which general business model frameworks cannot cover (Osterwalder/Pigneur 2010; Gassmann et al. 2014; Remané et al. 2017b; Taran et al. 2016). Furthermore, we contribute with refined business model patterns and transformation paths between them in the context of product-service systems (P6). Besides the thesis has a methodical contribution. In three publications (P3 – P5), we show how to combine different approaches, i.e., case study (Yin 2014), case survey (Larsson 1993), iterative taxonomy development (Nickerson et al. 2013), and design science (Hevner 2007), to derive context-specific business model taxonomies and patterns.

In this way, findings address several calls for research on business model patterns and taxonomies. The taxonomies and patters function as a systematic and exhaustive business model classification structure (Fielt 2013). The taxonomies and patterns propose and characterize specific sub-classes of business models (Veit et al. 2014). They enable the formalization and conceptual modeling of business models (Osterwalder/Pigneur 2013). We further address calls for research on business model patterns in different evolving industries (Remané et al. 2017b; Zott et al. 2011).

Third, the results contribute to the literature on **business model innovation**. The hierarchical taxonomy of business model patterns and the business model taxonomies and patterns for Industry 4.0 (P3 and P4) and blockchain (P5) help to understand business model innovations. Taxonomies, patterns, and related cases show how firms leverage IT to innovate business models and how firms implement these new business models (P3 – P5). The identified business model innovation transformation paths for product-service systems show how firms transform from pattern A to a more service-driven pattern B (P6). Thus, findings further contribute to research on business model innovation and servitization. Moreover, findings reveal how to conduct open business model innovation (P7). We contribute by combining open innovation and business model innovation, by expanding the perspective with the concept of innomediaries, and by extending the 4I-framework (Frankenberger et al. 2013) with rich information about integration practices and activities for external stakeholders. We address several calls for research. The findings shed light on servitization and business model innovation (Foss/Saebi 2017) and show how to leverage IT to innovate traditional business models (Johnson et al. 2008; Bock/Wiener 2017). Taxonomies, patterns, and related cases can further be used as tools to visualize business models (Osterwalder/Pigneur 2013; Veit et al. 2014) and support business model innovation (El Sawy/Pereira 2013).

Fourth, the results of this thesis contribute to the literature on **business model performance** and competitive advantage (P2). We show that some business model patterns correlate with higher or lower chances for startups' success. These findings quantitatively underline the extant qualitative characterized research on how business models impact firm performance (Shafer et al. 2005; Al-Debei/Avison 2010; Rietveld 2018; Afuah/Tucci 2001) and strengthen the understanding of business models as inimitable resources (Barney 1991; Teece 2018). Results address some calls for research. Findings contribute with a quantitative study on business model performance (Al-Debei/Avison 2010; Zott et al. 2011; Foss/Saebi 2017; Lussier/Pfeifer 2001) using a comprehensive, industry-independent lens (Lambert/Davidson 2013).

Summarizing, the findings of this thesis contribute primarily to research on business models, business model taxonomies and patterns, business model innovation, and business model performance. At the same time, contributions take place at intersections of research on business models and on digital transformation, value co-creation, servitization, product-service systems, Industry 4.0, blockchain, platforms, and strategic management. The contributions strengthen the role of the business model as an important theoretical construct in management research (Massa et al. 2017).

14.2 Implications for Practice

This thesis has several implications for practice, which firms can mostly apply when modeling, communicating, or innovating business models. First, taxonomies, patterns, and related cases support **modeling and communicating** ideas and business models. The hierarchical taxonomy of business model patterns (P1) makes patterns applicable in practice. The structure helps practitioners to navigate through business model patterns and to characterize their current business model. Specific business model taxonomies and patterns for Industry 4.0 (P3 and P4) and blockchain (P5) can likewise serve as a tool for modeling, characterizing, and communicating.

Second, practitioners can use the findings of this thesis to **support business model innovations** in different ways. Especially business model patterns can support **out-of-the-box thinking**, inspiration, and discovering new **opportunities**. Patterns can be used for questions such as: "What would our firm strategy be when applying pattern X?" This can support creativity and inspiration. Investigating patterns and related cases further bring up alternative business models and support analogical thinking (Gavetti/Rivkin 2005). Specific business model taxonomies and patterns for Industry 4.0 (P3 and P4) and blockchain (P5) can then help to evaluate the opportunities, i.e., the readiness of a current business model for applying Industry 4.0 or blockchain technology. For evaluating opportunities, practitioners can further rely on our quantitative analysis of business model patterns and startup success. Findings show that the freemium and the subscription business model pattern increase the chances of survival.

Moreover, findings illustrate how to **leverage advancements in IT** for new business models. Firms can learn from innovative business model patterns and related cases, for example, in the context of Industry 4.0 (P3 and P4) or blockchain (P5), how to digitally transform their business model. Identified **transformation paths** (P6) can guide the process of business model innovations, i.e., transforming from pattern A to pattern B towards innovative business models.

Finally, the thesis provides a practical process model and framework on **open business model innovation** (P7). The framework explains for each innovation phase activities and practices for integrating external stakeholders and, hence, support business model innovations. The article P7 further summarizes lessons learned for open business model innovation.

15 Future Research

In the course of our research on business model innovations, business model patterns, and transformation paths, several new research questions emerged, which are out of the scope of this thesis and provide fruitful avenues for future research.

Establishing business models as a profound theoretical construct for research. Our work provides the first step to promote the business model as a theoretical construct for research. Taxonomies and patterns are a basis for construct clarity and theory building (Rich 1992; Doty/Glick 1994). However, more research is needed to interweave the different interpretations of business models (Massa et al. 2017). Researchers can build on identified taxonomies and patterns to describe and characterize business models in more detail. Hence, they can increase construct clarity and support theory building. Thus, business models can serve as a foundation for various topics in future information systems and management research.

Extending the business model pattern language. Future research can extend our initial language and generate a comprehensive business model pattern language. Similar to Alexander (1977, 1999) proposed for buildings and towns, a business model pattern language can describe different patterns on different levels of abstractions and their relations. Our hierarchical taxonomy (P1) and context-specific taxonomies (P3 – P5) can be seen as a first step. However, a language can include more, similar to an ontology. It can include more relationships in addition to in heritage, for example, exclusion, where two business model patterns are not compatible. The language further needs to be extendable. Extend taxonomies and patterns (P1, P3 – P6) cover environments under change, i.e., Industry 4.0, product-service systems, and blockchain technology. New identified business model patterns can address sparse areas of the hierarchical taxonomy and capture new emerging patterns in industries under change or even new emerging industries. In addition, the ontology-oriented pattern language can include business model distances. Future research can investigate a change indicator between two patterns. This indicator points to needed changes for firms when innovating from business model pattern A to business model pattern B. Hence, a business model pattern language with its relations between patterns and its extendable nature provides several issues for future research.

Measuring the digital maturity of business models. Our work can serve as a basis for developing a model for assessing the digital maturity of business models. The identified business model taxonomies and patterns and transformation paths in Industry 4.0 (P3 and P4) and blockchain (P5) and for product-service systems (P6) can serve as the first indicators of how digitally transformed a business model is. However, future research can build on these approaches and develop a generally applicable maturity model for digital business models. The maturity model can consider different dimensions of digital business models building on taxonomies of this thesis.

Role of information systems in business model innovation processes. The findings of this thesis in the area of open business model innovation can serve as a basis for analyzing the role of information systems in business model innovation processes. Findings already indicate that advancements in IT support collaboration and co-creation. However, digital projects also increase complexity and digital business model innovations need more diverse experts. Future research can analyze how advancements in IT change approaches in business model innovation and processes itself as well as collaboration practices with external stakeholders in open innovation. We might even experience a development towards service platforms for open business model innovations, which is a fruitful area to study.

More extensive quantitative studies on business model performance. Finally, this thesis builds on more qualitative than quantitative approaches. For example, when analyzing business models for Industry 4.0, product-service systems, or blockchain, we did not include performance measures (P3 – P6). Likewise, business model research is rather qualitative. Our quantitative analysis of business model performance with startups is the first step towards quantitative research on business models (P2). Still, more research is needed to provide profound guidance for practitioners and strong theoretical contributions. Future research can, for example, investigate the direct profit effects and influences on the competitive advantage of business model patterns in incumbent firms in different industries and contexts. Research needs profound econometric analyses to shed light on this understudied area.

16 Conclusion

Firms increasingly compete on business models, which makes their innovation crucial for long-term success. However, many business model innovations fail. Therefore, this thesis develops an empirical understanding of business model innovations of incumbent firms by analyzing business model patterns and transformation paths. We structured literature on patterns and showed that business models matter for firm performance. We developed business model taxonomies and patterns for two emerging IT-driven contexts: Industry 4.0 and blockchain technology. We added a dynamic perspective on business models by determining transformation paths between patterns and developing a practical processes framework for business model innovation. Results contribute to strategy and information systems literature by supporting business models as a theoretical construct for research and showing how IT shapes new business models, transformation paths, and innovation processes. For practice, we provide guidelines for innovative business models, paths for its transformation, and processes for its innovation. Future research can extend findings on various facets of business models and its innovation towards a profound theory on business models.

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Appendix. Published Articles in Original Format

Appendix A. A Hierarchical Taxonomy of Business Model Patterns (P1)

Electronic Markets
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RESEARCH PAPER

A hierarchical taxonomy of business model patterns

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Abstract
Although business model innovation (BMI) is essential to remaining competitive, many firms fail at it. A promising approach is building on reoccurring successful solutions – business model patterns (BMP) – as a blueprint for BMI. However, existing patterns face constraints subject to a high diversity and overlaps among patterns. In addition, literature do not consider relations among BMPs, which limits their potential for BMI. This paper develops a hierarchical taxonomy of BMPs including generalizations and specializations based on inheritance. We conduct a literature review to identify patterns and a cluster analysis to create an inductive structure, followed by a qualitative analysis. The resulting hierarchical taxonomy includes 194 elements. It is the first hierarchical taxonomy of BMPs. The hierarchy addresses the diversity of patterns and overlaps with inheritance. It aids research to structure and understand BMPs. For practice, the taxonomy allows for the application of patterns and supports BMI.

Keywords Business model · Business model pattern · Taxonomy · Hierarchical structure · Cluster analysis

JEL classifications O310 Innovation and Invention · Processes and Incentives

Introduction

Market dynamics are changing at an ever-increasing pace and thus becoming more demanding for firms (D'Aveni et al. 2010; Teece 2018; El Sawy and Pereira 2013). Better information and a broader selection of firms has led to a shift in bargaining power toward customers (Teece 2010). To win this battle for customer attention, firms need to shorten development cycles, which increases competition and turbulence in the market (Schneider and Spieth 2014; Teece 2018). Consequently, firms have to adapt to market dynamics and changing demand continuously.

Business models (BMs) are a crucial aspect to remaining competitive in these turbulent markets (Martins et al. 2015; de Reuver et al. 2013; De Reuver et al. 2009). A BM defines how firms create, deliver, and capture value in a market (Teece 2010).[1] Firms adapt BMs to cope with changing market dynamics by harmonizing the business strategy, internal processes, and information systems (Al-Debei and Avison 2010; Schneider and Spieth 2014; Teece 2018).

However, many firms fail when trying to align BM change with dynamic market requirements (Christensen et al. 2016). Changing an entire BM can involve enormous transformations for an organization (Foss and Saebi 2017). Thus, it is not surprising that this concept of BM change or adaption, termed as Business Model Innovation (BMI), enjoys increasing popularity (Foss and Saebi 2017). However, practitioners often build on trial-and-error experimentation to innovate their BM and fail likewise (Martins et al. 2015; Chesbrough 2010; Sosna et al. 2010; Morris et al. 2005). One reason is a lack of supporting frameworks and tools (Osterwalder and Pigneur 2013; Veit et al. 2014; Heikkilä et al. 2016; Weking et al. 2018a).

This article is part of the Topical Collection on *Business model innovation: Tools and innovation patterns*

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[1] This paper uses BMs as formal conceptual representations (Massa et al. 2017).

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A promising approach that supports BMI is learning from recurring phenomena that have proven to be successful in the past in different industries or contexts: business model patterns (BMPs) (Amshoff et al. 2015). BMPs describe successful BM instances or components of it that are applicable on other firms (Osterwalder and Pigneur 2010; Gassmann et al. 2014; Amshoff et al. 2015). BMPs can either be used in isolation or in a combination to form a new complete BM or describe a BM instance (Osterwalder and Pigneur 2010; Böhm et al. 2017). We see BM instances as concrete real world BMs (Osterwalder et al. 2005). BMPs sometimes appear under different names, for instance BM archetypes (Bocken et al. 2014; Weill et al. 2005; Eickhoff et al. 2017; Weking et al. 2018b) or BM configurations (Taran et al. 2016). Gassmann et al. (2014) found that 90% of BMIs in practice are a combination of existing BMPs.

However, current BMP literature faces limitations that restrict their applicability in research and practice. There is a variety of different BMP (i.e., Gassmann et al. (2014), Taran et al. (2016) or Remané et al. (2017), which differ in two dimensions. First, BMPs differ in the covered BM elements. On the one hand, a BMP can relate to one distinct element of a BM, such as the pattern *channel maximization* (Remané et al. 2017), which refers to the BM element *value delivery*. On the other hand, a BMP can relate to several BM elements such as the pattern *merchant model* (Remané et al. 2017), which addresses the BM elements *value creation*, *delivery* and *capture*. Second, BMPs differ in the level of abstraction. BMPs can address a low level of abstraction, such as the pattern *flexible pricing* (Remané et al. 2017) or they can approach a high level of abstraction, such as the pattern *multi-sided platform* (Osterwalder and Pigneur 2010). Further, an *HR broker* is a specific form of a *multi-sided platform*, where a platform provider matches buyers and sellers. Thus, these differences in covered elements and level of abstraction lead to BMPs overlapping in terms of content and substance. Hence, this variety of BMPs leads to overlaps in both dimensions: the degree of coverage and the content resulting from differences in the level of abstraction. Ultimately, this results in a complex and chaotic collection of BMPs, which is hard to use when innovating a BM.

Two contributions aim to resolve this complex collection by structuring BMPs (Taran et al. 2016; Remané et al. 2017). However, no framework provides a compelling categorization that addresses the variety of BMPs in the covered BM elements, level of abstraction and resulting overlaps. To address these issues, it is important to characterize (Remané et al. 2017) and cluster individual BMPs (Taran et al. 2016), but also to identify a structure with relations among BMPs that describes many levels of abstraction with generalizations, specializations and inheritance.

The purpose of this work is to structure BMPs consistently and to leverage their potential for BMI. This paper develops a hierarchical taxonomy for BMPs. The taxonomy separates patterns present in the extant literature according to different degrees of coverage and levels of abstraction mitigating the issue of overlapping patterns. We build on an iterative taxonomy development approach (Nickerson et al. 2013) to tackle the complex field of BMPs by developing a hierarchical structure among BMPs. First, we perform an empirical-to-conceptual iteration with an agglomerative clustering of BMPs to generate an inductive structure (Kaufman and Rousseeuw 2009; Struyf et al. 1997). Second, we draw on a conceptual-to-empirical iteration with qualitative analysis to derive hierarchical levels within the structure. Scholars and practitioners can build on the hierarchical taxonomy to understand and use BMPs. The hierarchical structure helps to reduce the complexity of BMPs and to increase their applicability in the context of increased market dynamics.

Related work

Extant BM literature provides a variety of frameworks that characterize the BM of a firm (Täuscher and Abdelkafi 2017; El Sawy and Pereira 2013; Fielt 2013). Research differentiates between general and specific BM frameworks. General BM frameworks focus on common elements to describe a BM. El Sawy and Pereira (2013), for example, show 26 general BM approaches. Common examples are:

- the Business Model Canvas with nine dimensions (Osterwalder and Pigneur 2010),
- the Magic Triangle with four dimensions (Gassmann et al. 2014),
- the BM framework according to Abdelkafi et al. (2013) with five main elements,
- the unified BM framework (Al-Debei and Avison 2010) as a conceptual BM framework and
- the STOF model (Bouwman et al. 2008; de Reuver et al. 2013) as a service oriented BM framework.

All of them cover the following elements to characterize a BM instance: value proposition, value delivery, value creation and value capture. In addition, there are BM frameworks that do not directly address value-based elements, but specific aspects. The casual loop diagram (Casadesus-Masanell and Ricart 2010; Casadesus-Masanell and Ricart 2011) as a logic oriented BM framework uses choices and consequences to describe BM instances and highlights their reinforcing cycles. The matrix-shaped BM framework according to Weill et al. (2005) focuses on four BM archetypes (i.e., *creator*, *distributor*, *landlord* and *broker*) and the type of asset involved (i.e., *financial*, *physical*, *intangible* and *human*) (Weill et al. 2011). IBM's component business model (Chesbrough 2010; Pohle et al. 2005) illustrates the category of specialization-focused BM frameworks. It includes an accountability level (i.e., *direct*, *control* and *execute*) and does not cover a direct value capture dimension. Besides specialized BM frameworks, there are also BM frameworks tailored toward a specific context: digital BMs (Bock and Wiener 2017), big data (Hartmann et al. 2016), FinTechs (Eickhoff et al. 2017), car sharing (Remané et al. 2016), platform BMs (Täuscher and Laudien 2018), or sustainable BMs (Upward and Jones 2016). The large amount of frameworks as well as their differences emphasize the ambiguity of the concept of BMs.

BMPs are a promising solution to reduce the complexity in characterizing BMs with BM frameworks. BM literature provides many different collections of BMPs with diverse amounts of BMPs. Osterwalder and Pigneur (2010) deduce five BMPs. Gassmann et al. (2014) define 55 BMPs. Both use their BM framework to derive and describe typical BMPs including related example cases. Two contributions build on BMPs from literature. Taran et al. (2016) initially found 97 BMPs and conclude with 71 different BMPs. Remané et al. (2017) started with 356 BMPs and result with 182 different BMPs.

However, the current literature about BMPs has two main limitations. First, the multitude of general BM frameworks leads to a wide range of BMPs that address different BM elements, i.e., one or many. Consequently, some patterns include only a few BM elements, whereas others describe holistic BMs. Osterwalder and Pigneur (2010) deduce five BMPs that change the general setup of a BM and influence all BM elements and many areas of a firm (e.g., *long tail*, *multi-sided platform* or *open business model*). Gassmann et al. (2014) define BMPs that vary in their addressed BM elements. Some BMPs focus on a few elements of a BM. Examples are the patterns *pay what you want* and *subscription* addressing mainly value capture mechanisms, and *white label* addresses mainly the value proposition. Others affect all elements of a BM, such as *no frills*, *peer-to-peer* or *two-sided market*. Likewise, the work of Taran et al. (2016) covers BMPs influencing all BM elements, such as *broker* (i.e., "bring together buyers and sellers and facilitate transactions") and BMPs influencing only a few BM elements. *Channel maximization* (i.e., "product is distributed through as many channels as possible to create the broadest distribution possible"), for example, refers to the value delivery. Remané et al. (2017) similarly covers very different BMPs. Examples are *e-mail* (i.e., "communicate with stakeholders via e-mails rather than print and mail") that influences the value delivery only, whereas *connection* (i.e., "provide physical and/or virtual network infrastructure to gain (internet) access") or *software firms* (i.e., "create software and license/sell it") describe holistic BMs.

Second, there is a variety in the level of abstraction of BMPs. Some are specializations, while others are generalizations of BMPs. *Multi-sided platforms*, for example, bring together two or more customer segments (Hein et al. 2018c). The presence of each segment creates value for the other segments (Remané et al. 2017; Osterwalder and Pigneur 2010). Thus, *multi-sided platforms* are generalizations of *brokerage* that define two segments as buyers and sellers and add a commission fee (Remané et al. 2017; Weill et al. 2005). Further specializations are *financial broker*, *HR broker*, *physical broker* and *information broker* (Remané et al. 2017; Weill et al. 2005). Another example is *subscription* where customers regularly pay upfront for products or services (Remané et al. 2017; Rappa 2001). Specializations are *flat-rate*, where the customer receives unlimited access and *membership* where the access to products or services and the time-dependent payment is the focus (Remané et al. 2017; Gassmann et al. 2014; Tuff and Wunker 2010). These differences in the level of abstraction of BMPs and in the covered BM elements leads to overlapping BMPs and increased complexity. Collections of BMPs are hard to apply for BMIs.

Two contributions aim to reduce this complexity by creating a comprehensive structure for characterizing BMPs. Taran et al. (2016) introduce the five-V framework. It clusters the 71 BMPs into five dimensions: value proposition, value segment, value configuration, value network, and value capture. Remané et al. (2017) introduce a matrix-shaped BM taxonomy. They used BMPs to create a morphological box for characterizing BMs. The BM framework has four initial dimensions based on Günzel and Holm (2013): value proposition, value delivery, value creation and value capture (Remané et al. 2017). Remané et al. (2017) include two hierarchical levels in the form of *prototypical* as holistic patterns and *solution* patterns as specific building blocks. Both studies focus on clustering and classifying existing BMPs by deriving typologies or BM frameworks to reduce complexity (Taran et al. 2016; Remané et al. 2017). They both cover the basic four elements ranging from value proposition, to value delivery, to value creation, and value capture. They can characterize BMPs as well as BM instances from practice.

However, both frameworks focus only on characterizing BMPs. BM literature address neither the variety in covered BM elements of BMPs nor the diversity in the level of abstraction of BMPs nor the resulting overlaps among BMPs. Likewise, general BM frameworks are not able to address these issues. The four BM elements are not enough to address the main drawbacks of BMPs. Current literature only characterizes individual BMPs. Despite the importance of reducing complexity among BMPs by structuring, no paper has taken into account the relations and hierarchical structures among BMPs yet. Thus, this paper focuses on relations among BMPs in the form of a hierarchical taxonomy of BMPs covering specializations and generalizations based on the inheritance of characteristics of BMPs to address the differences in covered BM elements, the diverse abstraction levels, and the resulting overlaps among BMPs.

Research method

We followed a two-step research approach. First, we used a structured literature review (Webster and Watson 2002) to identify a comprehensive set of BMPs. Second, we used an iterative taxonomy development approach (Nickerson et al. 2013) to structure BMPs according to their relationships.

To identify articles with BMPs and similar constructs, we built on a literature review conducted by Remané et al. (2017). With a literature review according to Webster and Watson (2002), they identified 182 different BMPs out of 22 collections of BMPs and six reviews of BMP collections. To ensure the validity of their findings, we conducted a follow-up literature review based on Webster and Watson (2002) to cross validate and supplement their results. We used the four databases: ProQuest – Business, EBSCOhost, Science Direct and Scopus with the following search string: "'Business model*' AND (characteristics OR framework* OR taxonomy OR pattern* OR design OR development OR evolution)". We reviewed 776 papers, from which we have chosen 33 relevant articles. The search included articles in academic journals and conference proceedings written in English. We included only articles that focus on BMPs or similar constructs that meet the definition of BMPs. We found two more papers through a backward and forward search resulting in 35 papers.

In the coding process, two researchers iteratively checked and consolidated the BMPs presented in each publication to ensure intercoder reliability. We confirm the comprehensiveness of the list of BMPs according to Remané et al. (2017) and found only two additional patterns (i.e., *data as a service* and *R&D contractor*). Overall, we derived a set of 184 BMPs.

Next, two researchers coded each of the BMPs to verify their relevance according to three criteria. First, we include only patterns that cover at least one of nine building blocks of the Business Model Canvas (Osterwalder and Pigneur 2010). We have chosen the Business Model Canvas for this relevance criterion and the coding in the first iteration for three main reasons. First, it is a widely applied and practical BM framework (Massa et al. 2017). Second, it is a general BM framework and not specific for certain contexts. Third, with nine dimensions and two to ten characteristics each, it is very comprehensive (Osterwalder and Pigneur 2010). Thus, we exclude patterns that do not cover any BM element and do not meet the definition of BMPs. An excluded example is *e-mail* (i.e., "communicate with stakeholders via e-mails rather than print and mail") (Strauss and Frost 2016; Remané et al. 2017). Second, BMPs must not be specific for one industry. BMPs that are specific for one industry do not meet the definition of BMPs. An excluded example is *misdirection* for search engines (i.e., "send customers to locations different from what they initially searched for if the searched company did not pay sufficient listing fees to the search engine") (Clemons 2009; Remané et al. 2017). Other examples are BMPs for the electric vehicle industry (Bohnsack et al. 2014). Third, BMPs must not solely build on a business practice that has established itself as common practice. Excluded examples are *customer relationship management* (i.e., "collecting and integrating all information on each customer touch point") and *enterprise resource planning* (i.e., "use an integrated back office system to optimize business processes and thereby reduce cost") (Strauss and Frost 2016; Remané et al. 2017). To ensure intercoder reliability and internal validity, two researchers alternatively created (researcher A) and revised (researcher B) the coding until both agreed. We excluded 19 patterns and concluded with 164 BMPs for the taxonomy.

We built on the iterative taxonomy development according to Nickerson et al. (2013) to develop the hierarchical taxonomy (see Fig. 1). Before starting with the method, Nickerson et al. (2013) suggests to determine a meta-characteristic (step 1). However, since this paper creates an inductive hierarchical structure, we refrained from this step so as not to affect the inductive result. In the second step, we defined ending conditions (step 2). In addition to conditions defined by Nickerson et al. (2013), we added the following criteria due to our research purpose. First, the resulting classification structure should be a hierarchical tree, consisting of several branches and layers. Accordingly, one ending condition is that the taxonomy considers hierarchical relations among BMPs, including specializations and generalizations based on inheritance. Second, the taxonomy structure should be free from unnecessary branches or layers to have a concise taxonomy without redundancy or duplication (Nickerson et al. 2013).

The first iteration followed the empirical-to-conceptual approach (Nickerson et al. 2013). Since there is significant data available (164 BMPs), an inductive, empirical approach is suitable to create an initial structure (Nickerson et al. 2013). In step 4e, we included all objects, since we build on a quantitative approach. To identify common characteristics between BMPs (step 5e), we built on an agglomerative cluster analysis with a preceding coding. Two researchers iteratively coded all 164 BMPs according to the dimensions and characteristics defined by Osterwalder and Pigneur (2010). To not bias results, we choose this widely applied, general and comprehensive BM framework as a coding scheme. Table 1 shows the coding scheme with the BMP *razors/ blades* as an example (highlighted in italic). Within the coding, we stick to the definitions of the BMPs and the definitions' overall essence. For example, the essence of razors/ blades is not to offer *complements*, but to *lock-in* the customer with overpriced complements that are needed to use a product. During the coding, we noticed that some few characteristics fit for many BMPs and that some essential characteristics of BMPs were not part of the characteristics defined by Osterwalder and Pigneur (2010). Thus, we added some characteristics (*) to increase the discriminatory power and to ensure a collectively

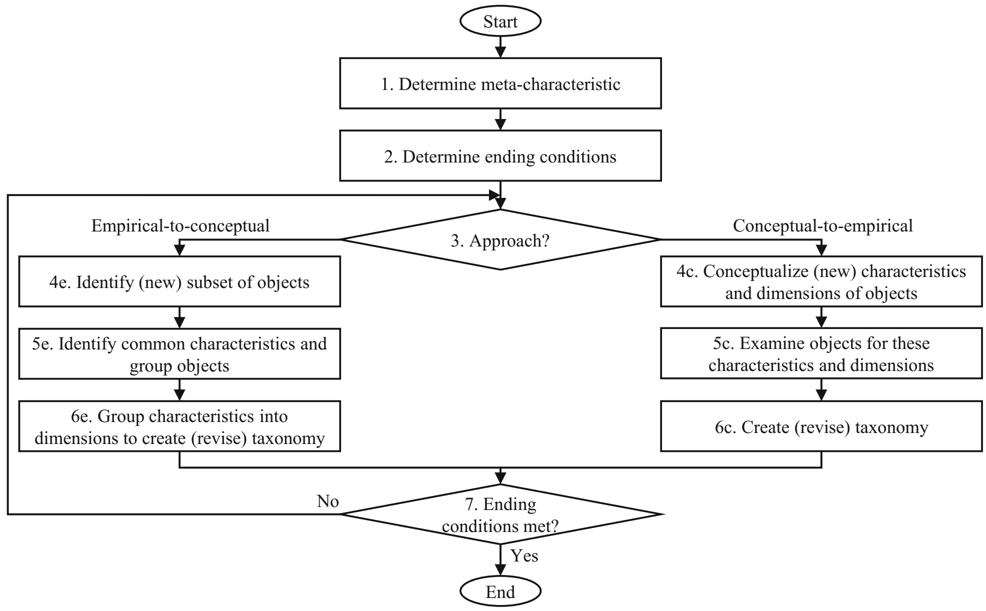


Fig. 1 Iterative taxonomy development approach (Nickerson et al. 2013)

exhaustive coding scheme (see Table 1). Two researchers alternatively created and revised the coding to ensure intercoder reliability. This resulted in three iterations of coding (researcher A) and revising (researcher B) all 164 BMPs until both agreed to the coding of all BMPs.

Thereafter, we used agglomerative clustering on the 164 coded BMPs to derive an initial inductive taxonomy (Nickerson et al. 2013). We used R with the package *cluster*, the function *agnes* and the *ward* method (Kaufman and Rousseeuw 2009; Struyf et al. 1997). It resulted in the best discriminatory power compared to *single*, *complete* or *average* linkage. We used the following indices to determine an optimal amount of clusters: McClain (McClain and Rao 1975), C-index (Hubert and Levin 1976), Silhouette (Rousseeuw 1987) and Dunn (Dunn 1974). The McClain and Silhouette index indicate seven clusters; the C-index suggests 27 clusters, whereas the Dunn index recommends 51 clusters. We applied all three suggestions to create a structure with three hierarchical levels, i.e., seven high-level clusters and 27 and 51 low-level clusters (step 6e). The left part of Fig. 2 shows the seven high-level clusters.

The second iteration followed a conceptual-to-empirical approach (Nickerson et al. 2013) to analyze and validate the clusters qualitatively. A qualitative analysis is necessary since a cluster analysis cannot recognize the different levels of abstraction of BMPs. Further, we validate the clusters qualitatively. Figure 2 summarizes the development process. It shows the quantities of BMPs in each cluster (1. Iteration) or subtree (2. Iteration) and includes initial names for clusters (1. Iteration). Two researchers studied all BMPs in one cluster to detect generalizations (step 4c) and specializations (step 5c) and to revise the taxonomy continuously (step 6c). BMPs with a higher level of abstraction became superordinate BMPs. If there was no high-level BMP that covers the intersection of low-level characteristics, we created a new BMP. We also split high-level clusters by building on lower-level clusters that resulted in 27 and 51 clusters from the analysis. For example, the value proposition cluster from the first iteration has 70 elements (see Fig. 2). Thus, we used the low-level clusters within the value proposition cluster to further differentiate BMPs. Subordinate clusters supported the separation between *payment/ pricing models*, *revenue streams*, *target customers*, *value propositions* and *development processes*. Other clusters could be used with almost no changes for the hierarchical structure (i.e., *merchant model*, *multi-sided platforms* and *value network*). For splitting and merging clusters and forming the hierarchical levels, we highly built on subordinate clusters from the first iteration that resulted from the analysis with 27 and 51 clusters. Eventually, the classification structure included hierarchical relations and all ending conditions were met (step 7).

Business model pattern taxonomy

The resulting hierarchical taxonomy of BMPs has 194 elements and comprises four hierarchical levels.[2] It is similar to a class diagram including the inheritance of properties, generalizations and specializations. BMPs on a lower level of abstraction inherit all properties of superior BMPs of this branch. BMPs on the same level do not exclude each other, since a BM covers several BMPs. A BM instance from practice can apply several BMPs on several levels. Speaking in terms of a UML class diagram, the inheritance in the taxonomy is composed of partial or incomplete specializations since we cannot

[2] Table 2 in the appendix shows the complete list of detailed definitions.

Table 1 Coding scheme based on Osterwalder and Pigneur (2010) with added characteristics (*) and an example coding of razors/ blade (italic) (own illustration)

Value Proposition	Revenue Streams	Customer Segments	Cost Structure	Customer Relationship	Partners	Resources	Activities	Distribution Channels
Price	*Asset/ service sale*	Segmented	Value-driven	Personal assistance	Strategic alliances between non-competitors	Physical	Problem solving	Indirect
Newness	Advertising	Mass market	Cost-driven	Self-service	Strategic partnerships between competitors	Intellectual/ Intangible	Production	Direct
Convenience/ usability	Brokerage fees	Niche market		Co-creation	Buyer-supplier relationships	Human	Platform/ network	
Risk reduction	Licensing	Multi-sided platforms		Communities		Financial		
Accessibility	Lending/ Renting/ Leasing			*Lock-In**		Data/ Information*		
Customization	Usage fee							
Getting the job done	Subscription fees							
Brand/ status								
Performance								
Cost reduction								
Complements*								
Experience*								

make sure that literature covers every possible BMP. The first level has eight high-level BMPs or subtrees, each one with several hierarchical layers. Figure 3 shows the first level of the hierarchical taxonomy. All elements that we added during the process and that are not directly defined as a BPM in literature are marked with an asterisk (*). In the following, we describe each of the eight subtrees.

Merchant model describes "wholesalers or retailers of goods and services" (Remané et al. 2017) (see Fig. 4). This BMP includes *supermarket*, where firms offer a great diversity of products with a low price (Gassmann et al. 2014) and three subordinate BMPs to further specify merchants in terms of what they offer (i.e., intangibles and/ or physical products) and how they offer it (i.e., *shop*). On the one hand, *merchant of intangibles* and *physical wholesaler* further specifies the asset of trading in intangibles and physical assets (Weill et al. 2005). An *e-retailer*, for example, sells physical assets solely online (Rappa 2001; Wirtz et al. 2010). On the other hand, a *shop* describes that a provider uses a shop to offer his value proposition. *Bricks and clicks*, for example, defines that a shop has an online and offline presence (Johnson 2010).

Multi-sided platforms "bring together two or more distinct but interdependent groups of customers, where the presence of each group creates value for the other groups" (Remané et al. 2017) (see Fig. 5). This BMP include specialized platforms, such as *collaboration platforms* and *trust intermediaries*, as well as various forms of *brokerage* and *portals*. Brokerage concentrates on buyers and sellers only and charges a transaction fee. Brokers can again have specific assets (*broker of specific assets*) and/ or can operate exclusively on the internet (*internet platform*). *Portals* bring together contents from diverse sources. For example, an *e-mall* aggregates several e-shops, whereas a search engine can be a *horizontal portal*.

Customer group comprises BMPs that focus on a certain customer group or market segment (see Fig. 6). It generalizes BMPs, such as *long tail*, which focuses on offering a large number of niche products, where each sells relatively infrequently (Osterwalder and Pigneur 2010). Other specializations are *affinity clubs* where a product is exclusively offered to members, *aikido* where offerings a are opposite to the offering of the competition, and *own the undesirable* where the target customer group might not appear immediately attractive (Remané et al. 2017; Gassmann et al. 2014). We added one BMPs in this subtree: *serve convenience seekers* targets customers valuing convenience over all other attributes. It involves offering more convenient, simple products (i.e., *dial down features*) and offering products in a convenient way (i.e., *one-stop convenient shopping*).

The subtree *Payment/ pricing model* cover BMPs that define how a price can be compounded and determined (see Fig. 7). It includes general pricing models, such as *auction*, *disaggregated pricing* or *freemium*, and specialized ones for low prices (*sell at low prices*). Examples for general pricing

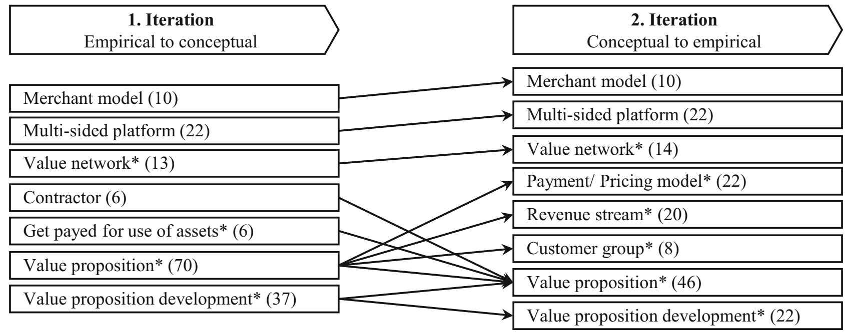


Fig. 2 Development of the hierarchical structure (* not a BMP from literature) (own illustration)

models are *demand collection system* where a buyer's final bidding is arranged (Rappa 2001; Remané et al. 2017) and *disaggregated pricing* where customers can buy exactly what they want (Tuff and Wunker 2010; Remané et al. 2017). Examples for low pricing are *buying club* where providers use high volumes to negotiate discounts (Linder and Cantrell 2000; Remané et al. 2017) and *under the umbrella pricing* where provider underprice market leaders (Linder and Cantrell 2000; Remané et al. 2017). Some patterns, such as *add-on*, *free*, *freemium* or *product sales*, are closely related to the value proposition. However, the essence of these patterns is the pricing, which leads to a changed value proposition in a second step. Therefore, the patterns are specializations of the *payment/ pricing model*.

Revenue streams describe how the BM generates revenues (see Fig. 8). In contrast to *payment/ pricing models*, *revenue streams* utilize pricing models to generate revenue. This can include general approaches (i.e., *negative operating cycle* and *scaled transactions*), revenues from advertising, revenues from lending out assets and revenues from usage fees. *Lending/ renting/ leasing* is "temporarily granting someone the (exclusive) right to use a particular asset for a fixed period in return for a fee" (Osterwalder and Pigneur 2010). Especially for this BMP, we found further differentiating patterns, for instance allowing customers to use software for a continuous service fee (*application service providers*) or other kinds of *landlords*. In *subscription* models, we found *trust services*. They include memberships with a subscription fee and specific code of conduct (Rappa 2001). With *usage fees* a customer pays depends on a certain variable, such as (short) time usage (*pay per use*) or the performance/ result of the product usage (*performance-based contracting*). Accordingly, the pricing for *usage fee* is variable, while the pricing for *lending/ renting/ leasing* builds on a fixed characteristic, such as a period of time.

The *value network* as a BMP involves changes in the *actors* of the value network or changes in *how* they interact (see Fig. 9). This also includes extending the value network with new forms of advertising (*buy advertising*), cover more parts of the value chain (*integrator*), and more closely link different actors of the supply chain (*supply chain management*). Examples here are the *value chain integrator* that distributes information and coordinates activities in the value network and the *orchestrator* that concentrates in core competencies with outsourcing and coordinates the value chain (Andrew and Sirkin 2006; Remané et al. 2017). Other examples are sharing of infrastructure (*shared infrastructure*), revenues (*revenue sharing*) or risks (*risk sharing*).

The BMP *value proposition* can further specialize in the products or services provided or the way providers offer them (see Fig. 10). Examples are *lock-in, forced scarcity*, *breakthrough markets* or *reverse innovation* and *experience* or *premium* value propositions. On the one hand, *forced scarcity* describes the limitation of the supply to boost demand and prices (Tuff and Wunker 2010; Remané et al. 2017). *Breakthrough markets* means investing in new markets to achieve a short-time monopoly (Linder and Cantrell 2000), whereas *reverse innovation* refers to selling simple products in industrial countries that were developed for emerging markets (Gassmann et al. 2014). All three BMPs describe how to offer a value proposition. *Customization* BMs describe both the value proposition and how it is offered. It generalizes *mass customization* or customization for individual customers (i.e., *custom supplier of hardware* or *software*). On the other hand, various BMPs describe complementary products or services, for example: *digitally-charged products*, *cross selling*, *service-wrapped commodity*, *servitization of products* or *value-added reseller*. *Vertical portals* inherit properties of *content providers* since they specialize in a particular area by providing very deep content and functionality (Applegate 2001;

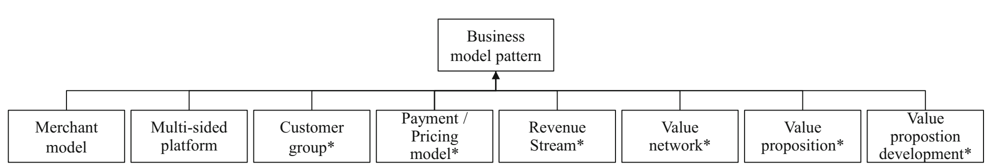


Fig. 3 First hierarchy level of taxonomy (* not a BMP from literature) (own illustration)

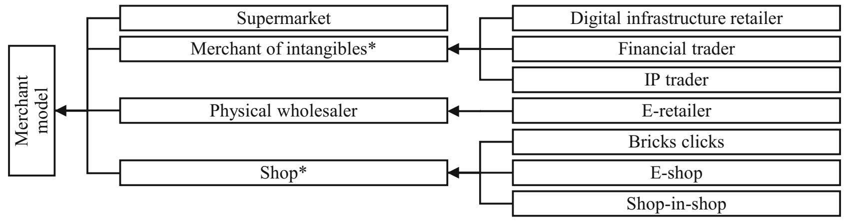


Fig. 4 Business model patterns of merchant models (own illustration)

Clemons 2009). In this way, the pattern creates an own value proposition and is more than a multi-sided platform connecting two customer groups. Another *content provider* as a BMP is *data as a service*, where data is a key resource and the offering of data is the value proposition (Hartmann et al. 2016). We derived the BMP *getting the job done* from Osterwalder and Pigneur (2010) as "helping a customer get certain jobs done". Thus, *advisors*, *audience measurement services*, *R&D contractors* and *search agents* are specializations. *R&D contractors* are engaged with technology development and building prototypes (Libaers et al. 2010).

Value proposition development describes how an offering is developed or produced (see Fig. 11). It generalizes BMPs, such as *open business model*, *open content*, *reverse engineering*, *user designed* or *crowdsourcing*. *Reverse engineering*, for example, describes to use information from a competitor's product to build a similar one. (Gassmann et al. 2014), whereas *trash-to-cash* is when used products are sold in different markets or used in new products (Gassmann et al. 2014). It further covers BMPs, such as *develop intangibles* (i.e., *digitization*, *entrepreneur*, *incomparable products/services* and *inventor*) and *internal use of data* that describes the development process (i.e., *business intelligence*, *context* and *knowledge management*). *Context* as a BMP produces a value proposition by sorting or aggregating information and provide information for a specific context (Wirtz et al. 2010). *Production* further specializes BMPs according to the type of asset (i.e., *produce physical products* and *produce intangibles*. It further includes the concrete production approach *from push to pull*. The patterns *crowdsourcing* and *user designed* are assigned here and not part of *value network* since they have a higher impact on development processes than on the value network.

Discussion

A current limitation of BMPs is that they have varying degrees of coverage in terms of BM elements and have different levels of abstraction. Some BMPs are straightforward and illustrate how firms can adapt their value stream (e.g., *membership*), while others touch all aspects of a BM (e.g., *multi-sided platform*). The consequence is that BMPs are overlapping, hard to compare, and thus not easy to use when innovating a business model. Existing BMP frameworks (Remané et al. 2017; Taran et al. 2016) are designed to illustrate and define patterns. Thus, they are not intended to analyze relations among BMPs or to address the variety in the degree of coverage, the different levels of abstraction and the overlaps. This paper builds on hierarchical relations among BMPs and creates a hierarchical taxonomy including generalizations and specializations based on inheritance to address all three issues. This work's literature review reveals 164 BMPs. Using an iterative taxonomy development method (Nickerson et al. 2013), we derive a hierarchical taxonomy with eight BMPs on the top level of abstraction and three further levels including more detailed BMPs. Since an instance of a BM in practice can comprise many BMPs, more than one BMP within one branch or subtree can apply to one complete instance of a BM.

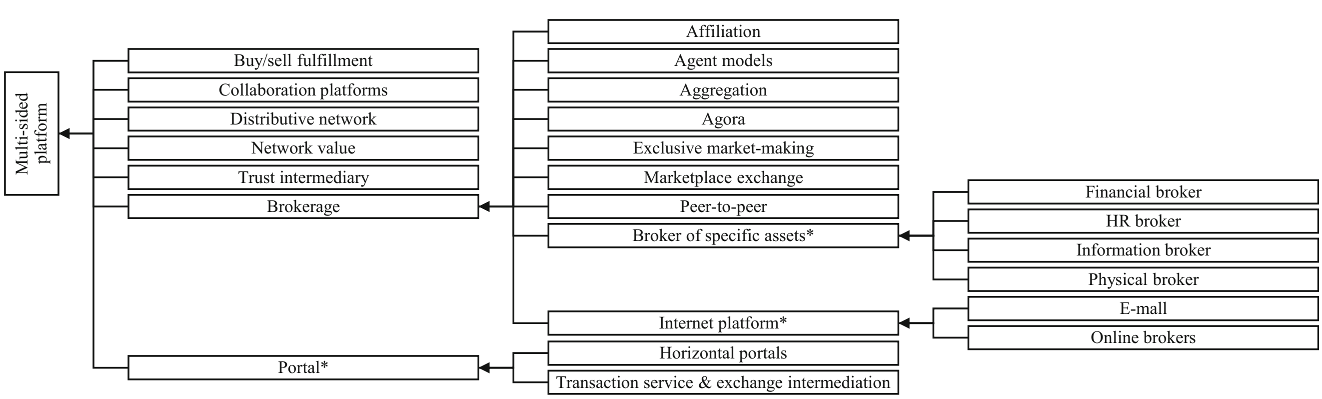


Fig. 5 Business model patterns of multi-sided platforms (own illustration)

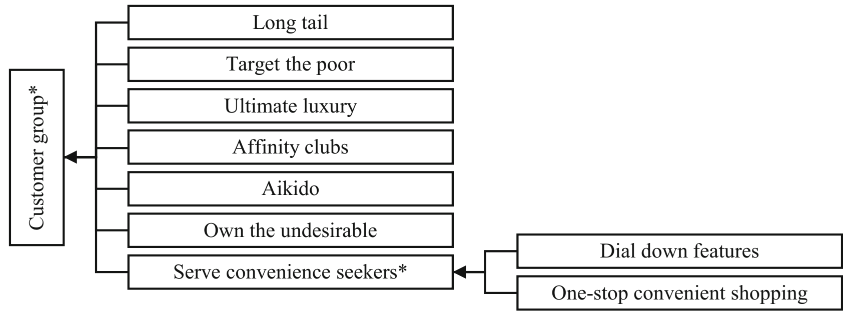


Fig. 6 Business model patterns specifying customer groups (own illustration)

The hierarchical taxonomy shows eight overarching BMPs that comprise dominant and holistic BMPs or cover common BM elements (i.e., *value proposition*, *value delivery*, *value creation* and *value capture*). On the one hand, two of eight high-level BMPs of the taxonomy cover holistic and well-known BMs. First, the *merchant model* describes wholesalers and retailers of goods and service (Remané et al. 2017). This BMP has existed for a long time and has been digitalized during e-commerce (Rappa 2001). Second, the *multi-sided platform* describes serving two or more customer segments, where the presence of each segment creates value for the other segments (Remané et al. 2017). This BMP similarly have been around for a long time (Osterwalder and Pigneur 2010). However, multi-sided platforms spread heavily with the rise and support of information technology (Parker et al. 2017; Hein et al. 2018a). Examples are Google, Facebook and Visa (Osterwalder and Pigneur 2010; Parker et al. 2017; Hein et al. 2018b; Schreieck et al. 2018). Both high-level BMPs, merchant model and multi-sided market, draw on a long history and show enormous business success in practice (Hein et al. 2016). The inductively derived taxonomy shows that both stand out as two very dominant BMPs in the BMP literature. On the other hand, the remaining six of eight high-level BMPs of the taxonomy address common *elements* of BM frameworks: value proposition, value delivery, value creation and value capture. The subtree *value proposition* addresses to the identically named BM element. The subtree *customer groups* refers to the value delivery, whereas the subtrees *value proposition development* and *value network* refer to the value creation. *Payment/ pricing models* and *revenue streams* address the value capture element. Consequently, the taxonomy confirms dominant and common elements of BM frameworks. Moreover, the taxonomy highlights two dominant BMPs. For both aspects, dominant BM elements and dominant BMPs, it provides further specifications with its hierarchical structure of BMPs.

The resulting hierarchical taxonomy of BMPs addresses three shortcomings of literature. First, it creates a structure for the various BMPs in literature including the relations among BMPs. It considers individual BMPs as well as

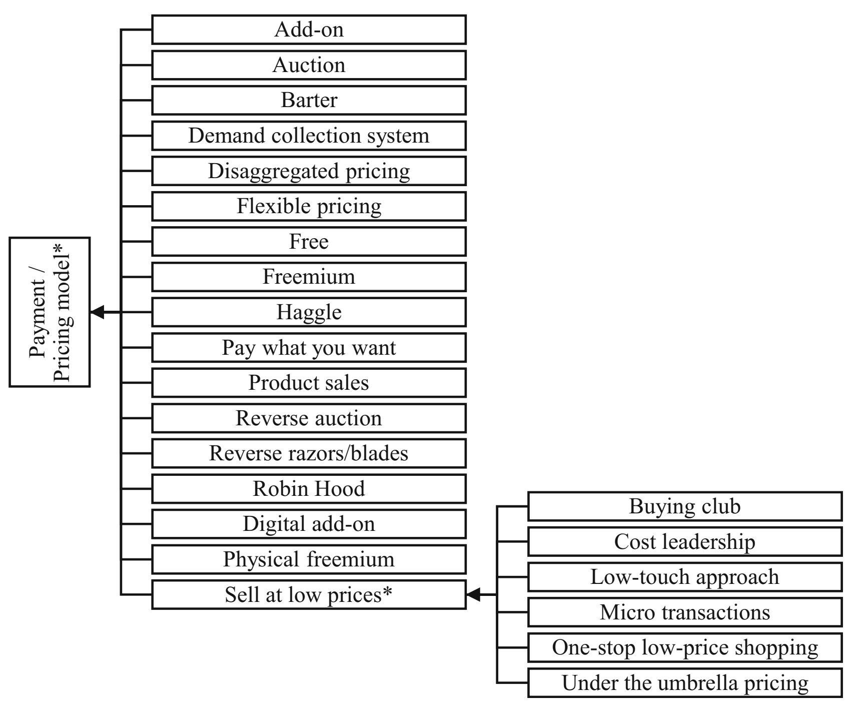


Fig. 7 Business model patterns specifying payment and pricing models (own illustration)

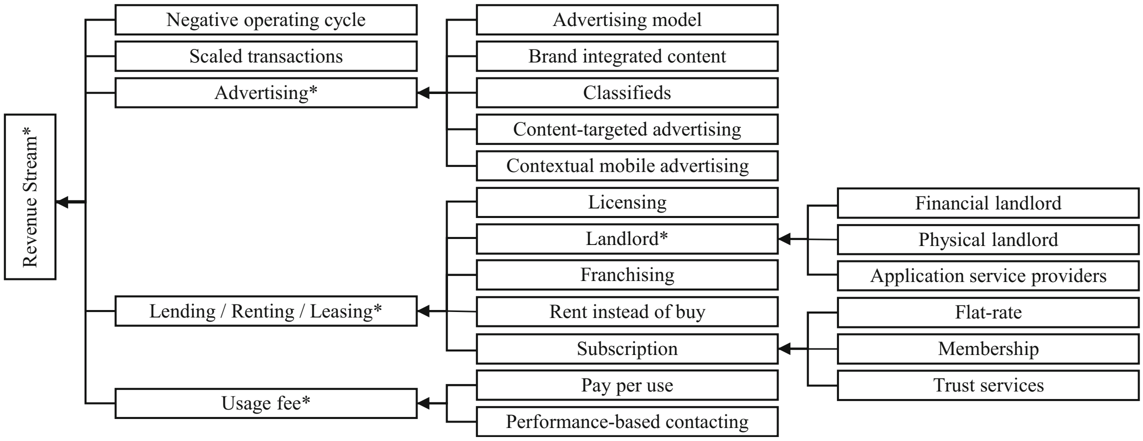
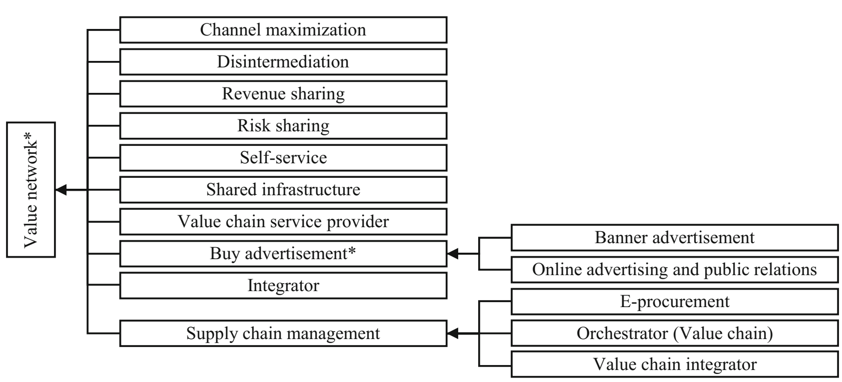


Fig. 8 Business model patterns specifying revenue streams (own illustration)

relations among them and thus mitigates the complexity of the large amount of BMPs in extant literature. Patterns are easier to find in the hierarchical structure than in an alphabetically sorted list. For example, if a user is looking for a pricing model, she can look at this subtree and see possible options. Second, the hierarchical structure takes into account the diversity of BMPs concerning their various degrees of coverage in terms of BM elements. The taxonomy with its different levels and relations among BMPs covers all kinds of different degrees of coverage and hence explains overlaps. The six of eight high-level BMPs that address common elements of BM frameworks and BMs clearly differentiate BMPs concerning their essence. The remaining two high-level BMPs (i.e., *merchant model* and *multi-sided market*) express two common holistic BMs. The taxonomy further specifies these BMs with lower-level BMPs, namely specializations. In this way, the taxonomy mitigates the various degrees of coverage in terms of BM elements by structuring BMPs according to BM elements and common holistic BMPs. Hence, it also clarifies overlaps in the dimension of coverage. Third, the taxonomy addresses the various hierarchical levels of BMPs with specializations and generalizations based on inheritance. BMPs inherit characteristics of superior BMPs and, thus, are specializations of BMPs on a higher level. While BMPs on a higher level in the taxonomy address a higher level of abstraction, BMPs on a lower level in the taxonomy also show a lower level of abstraction and cover BM elements in detail. In this way, it also clarifies overlaps in the dimension of abstraction levels. Summarizing, the taxonomy considers the variety in the covered BM elements of BMPs and the diversity in the level of abstraction of BMPs and incorporates overlapping BMPs with its hierarchical structure.

This work has three main implications for theory. First, to the best of our knowledge, this is the first inductively derived BM classification as well as the first classification considering relations among BMPs. It is the first BM taxonomy that address the diversity of BMPs concerning their various degrees of coverage, different hierarchical levels of BMPs, and overlaps of BMPs and relations among BMPs. The taxonomy helps to structure and understand the vast amount of BMPs available in literature. In contrast to existing BM frameworks (Osterwalder and Pigneur 2010; Gassmann et al. 2014), the hierarchical taxonomy of BMPs is able to characterize individual BMPs and BM instances from practice. Additionally, it allows for putting a BMP or BM instance in relation to other BMPs. In this way, BMs can be analyzed against the backdrop of other BMPs and in a higher order structure of BMPs with higher and lower levels of abstraction. Second, the taxonomy further serves as an extendable structure for future BMPs as well as current BMPs that literature does not cover yet. In

Fig. 9 Business model patterns specifying the value network (own illustration)



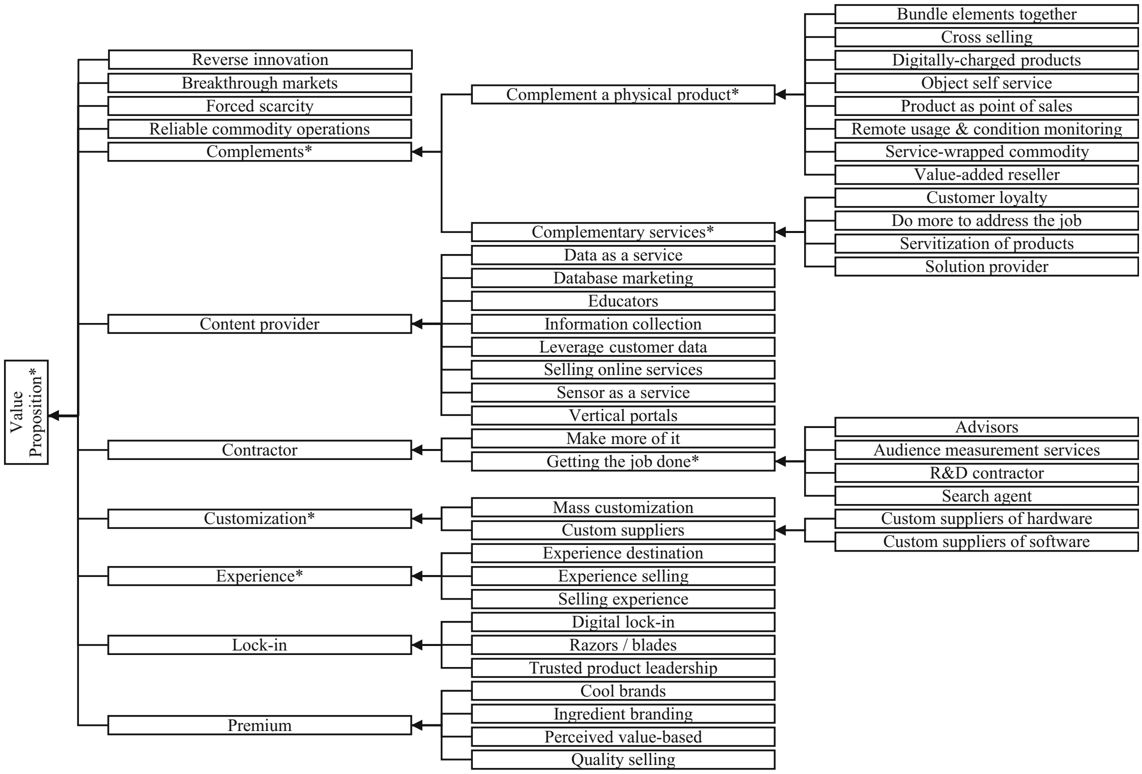


Fig. 10 Business model patterns specifying value propositions (own illustration)

contrast to existing BM frameworks, the taxonomy defines hierarchical dimensions for classifying BMPs and for describing them. The taxonomy functions as an overall structure. Currently, there are two holistic and overarching BMPs, namely merchant model and multi-sided market as well as six overarching BMPs that address different BM elements. Sparse parts of the taxonomy show possible areas for areas for new BMPs and future research. Third, the hierarchical structure as a supporting tool for BMI addresses several calls for research. The hierarchical taxonomy represents a holistic, exhaustive and systematic classification structure for BMs (Fielt 2013) including the derivation of specific sub-classes of BMs (Veit et al. 2014). It supports the conceptual modeling and formalization of BMs (Osterwalder and Pigneur 2013).

For practice, the hierarchical BM taxonomy allows for the application of BMPs. The taxonomy consists of BMPs with examples cases from practice in a hierarchical structure. The structure makes it easier to use than an alphabetically sorted list of BMPs, and the example cases provide the basis for analogical thinking (Gavetti and Rivkin 2005). Thus it helps practitioners to identify related BMPs (sharing the same parent node) to find a creative solution for a specific problem of

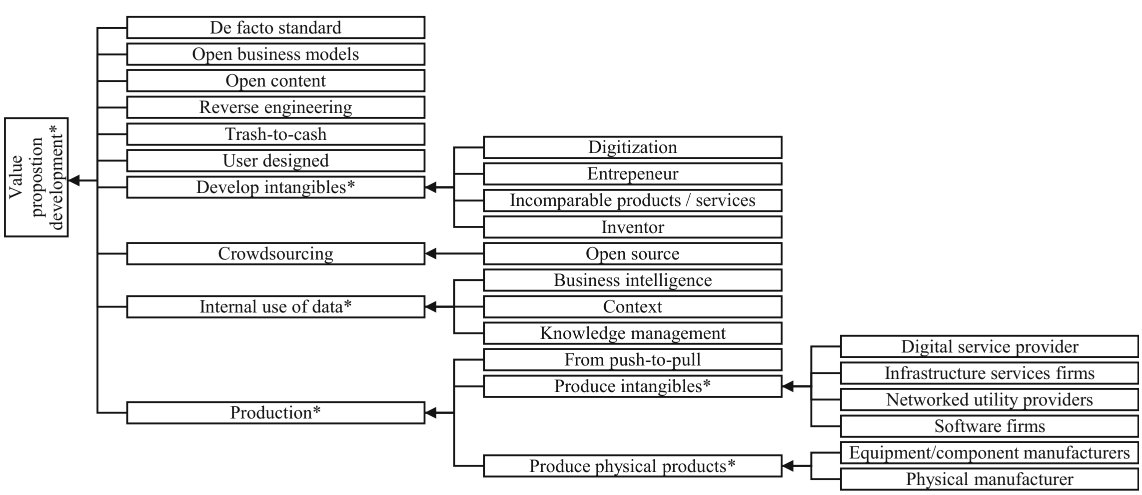


Fig. 11 Business model patterns specifying value proposition developments (own illustration)

their BM (e.g. *payment/ pricing models*). Furthermore, practitioners can characterize their current BM with the taxonomy of BMPs. They can decide for each branch and BMP if it is relevant for their current business or not. Then, they can identify analogies to BMPs and related example cases from literature. Practitioners can assess possible opportunities for BMI based on the taxonomy, the BMPs and example cases. For instance, they can assess related patterns within one branch as possible incremental BMI or analyze different branches as possible radical BMI. Here, the hierarchical taxonomy as a graphic tree helps to visualize the initial and planned combination of BMPs within an intended BMI. The taxonomy further shows the *path* that has to be traveled in the hierarchical structure for a certain BMI. This visualizes the changes of the current BM that are necessary to reach the target BM. In this way, the hierarchical taxonomy of BMPs can serve as a practical tool to support BMI. It addresses numerous calls for research. It helps to find options for BMI and new and viable BM alternatives as well as its visualization (Osterwalder and Pigneur 2013; Veit et al. 2014). The taxonomy supports incremental, i.e. similar BMPs within one branch, as well as radical changes of BMs, i.e. leaping from one branch to another, with example cases for each BMP (El Sawy and Pereira 2013).

This work has some limitations. First, the taxonomy solely relies on BMPs from literature. Thus, we cannot ensure that the taxonomy includes all available BMPs. There are probably new BMPs in practice that literature does not yet cover. However, we argue that the taxonomy is extendable and provides a good basic structure that is able to integrate future BMPs. Second, the taxonomy development process and especially the coding of BMPs as well as the second iteration with the conceptual to empirical approach can be subject to the researchers' interpretations of BMPs definitions. However, two researchers discussed the coding and matchings iteratively to prevent a possible bias. Third, there are limitations regarding the taxonomy's applicability in practice. Avoiding superficial analogies is important for strategy development (Gavetti and Rivkin 2005). An analogical case (source) has to be understood thoroughly before its similarities and differences can be assessed and it can be translated into a target case (Gavetti and Rivkin 2005). The taxonomy cannot consider the contextual factors and strategic path dependencies of an applying firm. Practitioners may find possible opportunities with example cases in the taxonomy. However, the taxonomy can only partly support practitioners in evaluating a specific BMP for their context and strategy by providing analogies in the forms of definitions and example cases (Gavetti and Rivkin 2005). Nevertheless, the taxonomy supports BMI in practice by structuring the many BMPs and make them utilizable. Fourth, the taxonomy has some sparse areas. Some dimensions of the structure are more detailed than others and include more BMPs. For example, *brokerage* as a specialization of *multi-sided platform* has many specializing BMPs, whereas *trust intermediaries* or *buy/ sell fulfillment* have no specializing BMPs. We can see that e-commerce BMPs (e.g., *online advertisement*) and digital BMPs dominate the taxonomy. The reason for this is that we included BMPs from literature only. This leads to promising areas for future research.

The hierarchical taxonomy for BMPs provides four main opportunities for future research. First, in order to address sparse areas of the taxonomy, future research can investigate new BMPs and extend the taxonomy. The taxonomy reveals two overarching and holistic BMPs, namely *merchant model* and *multi-sided platform*. Future research can investigate whether both types are dominant and successful types in practice and extend the hierarchical structure with new patters that further characterize both types. Likewise, the taxonomy shows six overarching BMPs that address BM elements. Future research can investigate in and extend these subtrees. For this purpose, the taxonomy serves as an overall structure and supports the identification of areas for new BMPs. Second, future research can use the taxonomy to describe certain BM instances and developments of a BMI. Like in practice, future research can apply the hierarchical taxonomy to characterize BM instances (e.g., an initial BM and a target BM) with existing BMPs to describe case studies, for example. Third, this work is a first step towards an ontology of BMPs and towards a BM distance measure. For now, the taxonomy includes hierarchical relations only. However, it would be interesting and further facilitate the usage of the taxonomy to include all kinds of relations. This ontology of BMPs would illustrate cross relations within the hierarchy, for instance BMPs that complement or exclude each other. Excluding examples are *disintermediation*, *integrator* and *orchestrator*. Whereas disintermediation and integrators aim to cover more parts of the value chain, an orchestrator tries to focus on core competencies, outsource remaining activities and only coordinate the value chain. An ontology of BMPs would further support a BM distance measure. With an indented BMI including an initial BM (initial combination of BMPs) and a target BM (target combination of BMPs), the hierarchical taxonomy and ontology can support the calculation of a distance between these BMs (combinations of BMPs). It would indicate how many changes of the current BM are necessary to reach the target BM and suggest how revolutionary the BMI would be. Fourth, the hierarchical taxonomy including the definitions of BMPs (see appendix Table 2) can be developed further as a practical tool. For example, a software tool implementing the hierarchical BM taxonomy would strengthen its practical relevance. In this way, the hierarchy can support practitioners with characterizing their current BM with BMPs and suggest possible opportunities for BMI. A hierarchical questionnaire based on the taxonomy can provide guidance for characterizing a firm's BM. Building on the current BMP combination, the tool can suggest possible opportunities for incremental BMI based on the hierarchy.

Possible opportunities for revolutionary BMI can be suggested based on a case study database of successful BMIs where the initial and the target BM is characterized with the hierarchical taxonomy of BMPs. Hence, the hierarchy of BMPs can serve as an underlying logic of a practitioner-oriented tool. Overall, the hierarchical taxonomy of BMPs opens up fruitful areas for future research with theoretical as well as practice relevance.

Conclusion

In increasingly turbulent markets and environments, BMs, their fit to a firm's strategy and the capability to innovate BMs are essential to remain competitive (Martins et al. 2015; Zott and Amit 2008). In research, the concepts of BMs and BMI are gaining more and more attention (Massa et al. 2017; Foss and Saebi 2017). However, innovating a BM is a complex task and many firms fail (Christensen et al. 2016). One approach to supporting BMI is building on successful solutions of the past, i.e. BMPs (Gassmann et al. 2014; Amshoff et al. 2015). However, BMPs and available collections of BMPs have three major limitations that restrict their applicability in research and practice. First, a large amount of BMPs exists with diverse degrees of coverage, i.e., covered BM elements. Second, BMPs show diverse levels of abstraction and resulting overlaps. Third, extant literature only characterize individual BMPs without considering the relations among BMPs to address diversity, hierarchy levels and overlaps. In order to mitigate these issues, this paper develops a hierarchical taxonomy of BMPs that includes generalizations and specializations among patterns based on inheritance to address this diverse degree of coverage, diverse hierarchy levels and overlapping BMPs.

In order to develop this hierarchical structure, we first build on a literature review (Webster and Watson 2002) to identify BMPs and second on an iterative taxonomy development approach (Nickerson et al. 2013). We coded all 164 BMPs according to Osterwalder and Pigneur (2010) and conducted an agglomerative cluster analysis, followed by a qualitative analysis to come up with an inductive structure. The resulting hierarchical taxonomy of BMPs includes 194 elements in its four levels of abstraction. On its highest level, it reveals two overarching, holistic BMPs (i.e., *merchant model* and *multi-sided market*) and six overarching elements of BMs. It is the first hierarchical taxonomy of BMPs, which takes into account relations among BMPs. The hierarchical structure reduces complexity by structuring the large amount of BMPs, respecting the diversity in the degree of coverage and abstraction levels and addresses overlaps with inheritance. It structures the complex field of BMPs and helps researchers to understand BMPs. For practice, the taxonomy allows for the application of BMPs, supports BMI and, thus, addresses several calls for research (Fielt 2013; Osterwalder and Pigneur 2013; Veit et al. 2014; El Sawy and Pereira 2013). The hierarchical taxonomy is extendable and, hence, serves as a robust foundation for further research with yet unidentified BMPs.

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Appendix

Table 2 Definitions of business model patterns (adapted from Remané et al. 2017) with added definitions (*)

Pattern	Definition	References
Add-on	Offer a basic product at a competitive price and charge for several extras	Gassmann et al. (2014)
Advertising model	Provide a product or service and mix it with advertising messages	Gassmann et al. (2014), Hanson and Kalyanam (2007), Rappa (2001), Tuff and Wunker (2010)
Advertising*	Generate revenues with advertising	Own definition
Advisors	Provide consulting and advise	Applegate (2001)
Affiliation	Refer customers to a third party and receive a commission for a specific transaction completed (e.g., click, give information, buy product)	Gassmann et al. (2014), Hanson and Kalyanam (2007), Rappa (2001)
Affinity clubs	Partner with membership associations and other affinity groups to offer a product exclusively to its members	Johnson (2010)

Table 2 (continued)

Pattern	Definition	References
Agent models	Represent the buyer or the seller and earn commissions for successful facilitation of transactions	Hanson and Kalyanam (2007), Strauss and Frost (2016)
Aggregation	Build a specific form of broker preselecting products/ services and target audience – hence, key process is matching of needs	Applegate (2001), Bienstock et al. (2002), Linder and Cantrell (2000), Rappa (2001), Tapscott et al. (2000)
Agora	Build a specific form of broker allowing buyer and seller to freely negotiate and assign value to goods – hence, key process is price discovery	Applegate (2001), Bienstock et al. (2002), Tapscott et al. (2000)
Aikido	Offer products to the customer that are the opposite of what the competitors are offering, thereby making competitor's strengths a weakness	Gassmann et al. (2014)
Application service providers	Allow customers to use software that is hosted on remote servers for continuous service fee	Applegate (2001), Eisenmann (2001)
Auction	Make customers name the maximum price they are willing to pay; the highest price wins the product or service	Applegate (2001), Bienstock et al. (2002), Gassmann et al. (2014), Hanson and Kalyanam (2007), Johnson (2010), Rappa (2001), Tapscott et al. (2000), Timmers (1998), Tuff and Wunker (2010)
Audience measurement services	Conduct market research on online audience as agency for other customers	Rappa (2001)
Banner advertising	Place advertising banners on websites	Hanson and Kalyanam (2007), Rappa (2001)
Barter	Allow customers to trade a non-monetary compensation in exchange for a product or service	Bienstock et al. (2002), Gassmann et al. (2014)
Brand integrated content	As manufacturer of other products create content for the sole basis of product placement	Rappa (2001)
Breakthrough markets	Invest in opening new markets to gain at least a temporary monopoly	Linder and Cantrell (2000)
Bricks + clicks	Integrate both an online (clicks) and an offline (bricks) presence to browse, order, and pick up products	Johnson (2010), Rappa (2001)
Broker of specific assets*	Broker that deal with specific assets	Own definition
Brokerage	Bring together and facilitate transactions between buyers and sellers, charging a fee for each successful transaction	Chatterjee (2013), Linder and Cantrell (2000), Johnson (2010), Tuff and Wunker (2010)
Bundle elements together	Make purchasing simple and more complete by packaging related products together	Hanson and Kalyanam (2007), Johnson (2010), Tuff and Wunker (2010)
Business intelligence	Gather secondary and primary information about competitors, markets, customers, and other entities to predict important information	Strauss and Frost (2016)
Business Model Pattern	describe components of successful BM instances or holistic successful BM instances that are applicable in other firms	Osterwalder and Pigneur (2010), Gassmann et al. (2014), Amshoff et al. (2015)
Buy advertising*	Promote your value proposition with advertising	Own definition
Buy/sell fulfilment	Take customer orders to buy or sell a product or service, including terms like price and delivery	Rappa (2001)
Buying club	Round up buyers with attractive prices and use purchase volume to gain discounts	Linder and Cantrell (2000)
Channel maximization	Leverage as many channels as possible to maximize revenues	Linder and Cantrell (2000)
Classifieds	List items for sale or things of interest and charge listing or membership fees in exchange	Rappa (2001)
Collaboration platforms	Provide a set of tools and an information environment for collaboration between enterprises	Timmers (1998)
Complement a physical product*	Offer a complement in addition to a physical product	Own definition
Complementary services*	Offer complementary services	Own definition
Complements*	Offer complementary products or services	Own definition
Content provider	Provide content such as information, digital products, and services	Applegate (2001), Clemons (2009), Eisenmann (2001), Strauss and Frost (2016), Weill and Vitale (2001), Wirtz et al. (2010)
Content-targeted advertising	Identify the meaning of a web page and then automatically deliver relevant ads when a user visits that page	Rappa (2001)
Context	Sort and/or aggregate available online information	Wirtz et al. (2010)

Table 2 (continued)

Pattern	Definition	References
Contextual mobile advertising	Tailor advertising to the context, e.g., location, preferences, or status	Clemons (2009)
Contractor	Sell services provided primarily by people, such as consulting, construction, education, personal care, package delivery, live entertainment, or healthcare	Weill et al. (2005)
Cool brands	Earn premium prices with competitive products through expert brand marketing	Hanson and Kalyanam (2007), Linder and Cantrell (2000)
Cost leadership	Keep variable costs low and sell high volumes at low prices	Tuff and Wunker (2010)
Cross selling	Offer complementary products in addition to the standard offering	Gassmann et al. (2014)
Crowdsourcing	Solve a problem by outsourcing it to the crowd (e.g., an internet community)	Gassmann et al. (2014), Johnson (2010)
Custom suppliers	Design, produce, and distribute customized products and services	Applegate (2001)
Custom suppliers of hardware	Produce and customize IT equipment or components	Applegate (2001)
Custom suppliers of software	Create and customize software and license/ sell it	Applegate (2001)
Customer group*	Focus on a certain customer group or market segment	Own definition
Customer loyalty	Increase customer loyalty by reward programs	Gassmann et al. (2014), Rappa (2001)
Customization*	Offer customized products or services	Own definition
Data as a service	Offer a provision of information to the customer as the value proposition. The key resource is represented by data.	Hartmann et al. (2016)
Database marketing	Collect, analyze and disseminate electronic information about customers, prospects, and products to increase profits	Strauss and Frost (2016)
De facto standard	Develop and use proprietary component technology to provide high product functionality, but also license it broadly throughout the industry to establish it as the dominant design	Linder and Cantrell (2000)
Demand collection system	Let prospective buyers make a final bid for a specified good or service and arrange fulfilment	Rappa (2001)
Develop intangibles*	Develop intangibles in an innovative way	Own definition
Dial down features	Target less-demanding consumers with products or services that may not be superior but are adequate and perhaps more convenient, simple, etc.	Johnson (2010)
Digital add-on	A physical asset is sold at a small margin; over time, the customer can purchase or activate any number of digital services with a higher margin	Fleisch et al. (2014)
Digital infrastructure retailers	Take control of inventory and sell digital infrastructure	Applegate (2001)
Digital lock-in	Use digital technologies to limit the compatibility of physical products and thus lock customers to your ecosystem	Fleisch et al. (2014)
Digital service provider	Produce and deliver a wide range of services online	Applegate (2001)
Digitally-charged products	Charge classic physical products with a bundle of new sensor-based digital services and position them with new value propositions	Fleisch et al. (2014)
Digitization	Offer a traditionally physical product as a digital version	Gassmann et al. (2014)
Disaggregated pricing	Allow customers to buy exactly – and only – what they want	Tuff and Wunker (2010)
Disintermediation	Deliver a product or service that has traditionally gone through an intermediary directly to a customer	Gassmann et al. (2014), Johnson (2010), Rappa (2001), Strauss and Frost (2016), Weill and Vitale (2001)
Distributive network	Provide infrastructure to connect other actors of the economy such as logistics, energy, mobility, or communication	Tapscott et al. (2000)
Do more to address the job	Look beyond your typical offering and address other jobs your customers are trying to get done	Johnson (2010)
Educators	Create an deliver educational offerings, often online	Applegate (2001)
E-Mall	Build a platform for a collection of e-shops, usually enhanced by a common umbrella, for example, of a well-known brand	Rappa (2001), Timmers (1998)
Entrepreneur	Create and sell financial assets, often creating and selling firms	Weill et al. (2005)

Table 2 (continued)

Pattern	Definition	References
E-procurement	Conduct tendering and procurement electronically	Strauss and Frost (2016), Timmers (1998)
E-retailer	Assume control of inventory, set a non-negotiable price, and sell physical products online	Applegate (2001), Eisenmann (2001), Rappa (2001), Wirtz et al. (2010)
E-shop	Build a web shop to sell products or services online	Gassmann et al. (2014), Strauss and Frost (2016), Timmers (1998)
Exclusive market-making	Bring together specific, highly targeted, qualified audiences for trading	Linder and Cantrell (2000)
Experience destination	Use a carefully designed environment to attract customers who pay premium prices	Gassmann et al. (2014), Linder and Cantrell (2000)
Experience selling	Allow the client to experience the product, often via a sales force and a pyramid commission structure; traditionally applied for cosmetic products	Linder and Cantrell (2000)
Experience*	Provide experiences	Own definition
Financial broker	Match buyers and sellers of financial assets	Weill et al. (2005)
Financial landlord	Let others use cash (or other financial assets) under certain (often time-limited) conditions	Linder and Cantrell (2000), Tuff and Wunker (2010), Weill et al. (2005)
Financial trader	Buy and sell financial assets without significantly transforming (or designing) them	Weill et al. (2005)
Flat-rate	Charge a fixed price and allow the customer unlimited access in exchange	Gassmann et al. (2014)
Flexible pricing	Vary prices for an offering based on demand	Strauss and Frost (2016), Tuff and Wunker (2010)
Forced scarcity	Limit the supply of offerings available to drive up demand and prices	Tuff and Wunker (2010)
Franchising	Allow franchises to use a business concept, including brand and products, in compensation for financial compensation	Gassmann et al. (2014)
Free	Provide customer with a free-of-charge offer and use other sources such as advertising to generate revenues	Linder and Cantrell (2000), Osterwalder and Pigneur (2010)
Freemium	Offer basic services for free, while charging a premium for advanced or special features	Gassmann et al. (2014), Hanson and Kalyanam (2007), Tuff and Wunker (2010)
From push-to-pull	Make production more flexible in order to ideally produce a product just when it is ordered and not upfront as stock article	Gassmann et al. (2014)
Getting the job done*	Helping a customer get certain jobs done	Osterwalder and Pigneur (2010)
Haggle	Allow the buyers to negotiate over the price	Bienstock et al. (2002)
Horizontal portals	Create a portal that provides a gateway to Internet's content and offerings, such as search engine, e-mails, news etc.	Applegate (2001), Eisenmann (2001), Rappa (2001), Strauss and Frost (2016)
HR broker	Match buyers and sellers of human services	Weill et al. (2005)
Incomparable products / services	Use deep R&D skills to develop and exploit proprietary technology to offer unique products that command high margins	Linder and Cantrell (2000)
Information broker	Match buyers and sellers of information or other intangible assets	Applegate (2001), Hartmann et al. (2016), Rappa (2001), Timmers (1998), Weill et al. (2005)
Information collection	Collect and commercialize information gathered from the Internet	Hanson and Kalyanam (2007)
Infrastructure services firms	Produce and deliver complementary services for the internet	Applegate (2001), Hartmann et al. (2016)
Ingredient branding	Build a brand of a product component that is part of an end product	Gassmann et al. (2014)
Integrator	Cover most parts of the value chain in-house in order to keep control of innovations, efficiency, etc.	Andrew and Sirkin (2006), Gassmann et al. (2014)
Internal use of data*	Use available data internally to develop new offerings	Own definition
Internet platform*	Broker that operate exclusively in the internet	Own definition
Inventor	Create and then sell intangible assets, such as patents and copyrights	Weill et al. (2005)
IP trader	Buy and sell intangible assets	Rappa (2001), Weill et al. (2005)
IT Equipment/ component manufacturers	Produce IT equipment and components	Applegate (2001)
Knowledge management		Strauss and Frost (2016)

Table 2 (continued)

Pattern	Definition	References
	Transform and store a company's data into useful information and knowledge	
Landlord*	Sell the right to use an asset	Own definition
Lending/ renting/ Leasing*	Temporarily granting someone the exclusive right to use a particular asset for a fixed period in return for a fee	Osterwalder and Pigneur (2010)
Leverage customer data	Collect customer data and use them commercially, e.g., for targeted advertising	Clemons (2009), Gassmann et al. (2014), Rappa (2001)
Licensing	License or otherwise get paid for limited use of intangible assets	Andrew and Sirkin (2006), Gassmann et al. (2014), Rappa (2001), Tuff and Wunker (2010), Weill et al. (2005)
Lock-in	Lock the customers to your ecosystem by strongly increasing the switching costs through high hurdles	Fleisch et al. (2014), Gassmann et al. (2014)
Long tail	Focus on selling a large number of niche products, each of which sells relatively infrequently	Gassmann et al. (2014), Osterwalder and Pigneur (2010)
Low-touch approach	Offer standardized, low-price version of a product or service that is traditionally customized and higher priced	Gassmann et al. (2014), Johnson (2010), Linder and Cantrell (2000)
Make more of it	Offer internal know-how and other resources also as external service to other companies	Gassmann et al. (2014)
Marketplace exchange	Build a specific form of broker also offering a full range of services covering the transaction process, from market assessment to negotiation and fulfilment for an industry consortium	Rappa (2001)
Mass customization	Customize a commodity products to the customers' specific preferences	Gassmann et al. (2014), Linder and Cantrell (2000), Strauss and Frost (2016)
Membership	Charge a time-based payment to allow access to locations, offerings or services that non-members do not have	Tuff and Wunker (2010)
Merchant model	Act as a wholesalers/ retailer of goods and services	Bienstock et al. (2002), Rappa (2001)
Merchant of intangibles*	Wholesalers or retailers of intangibles	Own definition
Micro transactions	Sell many items for as little as a dollar – or even only once cent – to drive impulse purchases	Tuff and Wunker (2010)
Multi-sided platforms	Bring together two or more distinct but interdependent groups of customers, where the presence of each group creates value for the other groups	Gassmann et al. (2014), Osterwalder and Pigneur (2010)
Negative operating cycle	Generate high profits by maintaining low inventory and having the customer pay up front	Gassmann et al. (2014), Johnson (2010), Tuff and Wunker (2010)
Network value	Provide a platform that leads to repeated purchases by a core group of loyal customers	Chatterjee (2013)
Networked utility providers	Create and distribute downloadable software programs that facilitate communication	Eisenmann (2001)
Object self service	Provide physical products with the ability to independently place orders on the internet	Fleisch et al. (2014)
One-stop convenient shopping	Use broad selection and ubiquitous access to attract busy buyers who will pay a premium for convenience	Linder and Cantrell (2000)
One-stop low-price shopping	Use low price and the convenience of broad selection to attract buyers, then convert volume into purchase discounts	Linder and Cantrell (2000)
Online advertising and public relations	Buy advertising on products or services of another companies	Strauss and Frost (2016)
Online brokers	Use the internet to facilitate a transaction between buyer and seller	Bienstock et al. (2002), Hartmann et al. (2016), Rappa (2001), Strauss and Frost (2016), Timmers (1998), Weill and Vitale (2001)
Open business models	Create innovations by systematically integrating partners into the company's R&D process	Gassmann et al. (2014), Osterwalder and Pigneur (2010)
Open content	Develop openly accessible content collaboratively by a global community of contributors who work voluntarily	Rappa (2001)
Open source	Develop a product not by a company, but by a public community with all information being available publicly	Gassmann et al. (2014), Rappa (2001), Tapscott et al. (2000)
Orchestrator (Value chain)	Focus on core competencies and outsource/ coordinate all other activities along the value chain	

Table 2 (continued)

Pattern	Definition	References
		Andrew and Sirkin (2006), Gassmann et al. (2014), Timmers (1998)
Own the undesirable	Seek to serve segments of the market that might not appear immediately attractive	Johnson (2010)
Pay per use	Charge for each use of a product or service	Gassmann et al. (2014), Hanson and Kalyanam (2007), Johnson (2010), Rappa (2001), Tuff and Wunker (2010)
Pay what you want	Invite customers to set the price they wish to pay	Gassmann et al. (2014), Tuff and Wunker (2010)
Payment/ pricing model*	Use a specific payment/ pricing model	Own definition
Peer-to-peer	Facilitates a transaction among peers, i.e., two or more consumers, through provision of a platform	Gassmann et al. (2014), Rappa (2001)
Perceived value-based	Position company's output as a "want" item and command a price premium – invest in knowledge professionals such as scientists, engineers, programmers, or data experts	Chatterjee (2013)
Performance-based contacting	Determine the fee for usage of a product not by frequency of use but rather by the quality of the result from the use	Fleisch et al. (2014), Gassmann et al. (2014),
Physical broker	Match buyers and sellers of physical assets	Weill et al. (2005)
Physical freemium	A physical asset is sold together with free digital services while charging a premium for advanced digital services	Fleisch et al. (2014)
Physical landlord	Sell the right to use a physical asset	Weill et al. (2005)
Physical manufacturer	Create and sell physical assets	Applegate (2001), Weill et al. (2005)
Physical wholesaler	Buy and sell physical assets	Rappa (2001), Weill et al. (2005)
Portal*	bring together contents from diverse sources	Own definition
Premium	Price at a higher margin than competitors for a superior product, offering, experience, service, or brand	Tuff and Wunker (2010)
Produce intangibles*	Produce intangibles	Own definition
Produce physical products*	Produce physical products	Own definition
Product as point of sales	Make physical products become sites of digital sales and marketing services that the customer consumes directly at the product or indirectly via another device	Fleisch et al. (2014)
Product sales	Sell a product for a fixed price	Hanson and Kalyanam (2007), Rappa (2001)
Production*	Produce a certain offering or produce it in a certain way	Own definition
Quality selling	Attract customers with high quality and / or hard to find products or services for premium prices	Hanson and Kalyanam (2007), Linder and Cantrell (2000)
R&D contractor	This type of firm is fully engaged in technology development in essence, building prototypes. Furthermore, these R&D contractors provide consulting services in highly technical subjects.	Libaers et al. (2010)
Razors/ blades	Offer a cheap or free basic product ("razors") together with complements ("blades") that are overpriced and thereby subsidize the basic product	Gassmann et al. (2014), Johnson (2010), Linder and Cantrell (2000)
Reliable commodity operations	Provide predictable commodity products or services for which customers are willing to pay a small premium, as they are reliable	Gassmann et al. (2014), Linder and Cantrell (2000)
Remote usage and condition monitoring	Equip products with digital technologies that allow to detect errors preventatively and monitor usage	Fleisch et al. (2014)
Rent instead of buy	Temporarily lend a product to the customer and charge a rent	Gassmann et al. (2014), Johnson (2010), Rappa (2001)
Revenue sharing	Share the revenues with other companies in order to create a symbiotic relationship	Gassmann et al. (2014), Hanson and Kalyanam (2007), Rappa (2001)
Revenue stream*	Use a specific revenue stream	Own definition
Reverse auction	Set a ceiling price for a product or service and have participants bid the price down	Bienstock et al. (2002), Johnson (2010)
Reverse engineering	Break down a product of competitors into its components and use this information to build a comparable product	Gassmann et al. (2014)
Reverse innovation		Gassmann et al. (2014)

Table 2 (continued)

Pattern	Definition	References
	Transfer cheaper products from less developed countries to more developed countries	
Reverse razors/ blades	Offer an expensive basic product ("razors") that allows for usage of cheap or even free complements ("blades")	Johnson (2010)
Risk sharing	Waive standard fees or costs if certain metrics are not achieved, but receive outsized gains when they are	Tuff and Wunker (2010)
Robin Hood	Charge wealthy customers more than poorer customers for a products or service	Gassmann et al. (2014)
Scaled transactions	Maximize margins by pursuing high-volume, large-scale transactions when unit costs are relatively fixed	Tuff and Wunker (2010)
Search agent	Search out the price and availability for a good service specified by the buyer	Rappa (2001)
Self-service	Delegate a part of the value chain to the client	Gassmann et al. (2014)
Sell at low prices*	Offer your value proposition with low prices	Own definition
Selling experience	Offer new experiences through participation in a community, often virtually	Clemons (2009)
Selling online services	Offer to use software services online	Clemons (2009)
Sensor as a service	Collect, process, and sell sensor data for a fee	Fleisch et al. (2014)
Serve convenience seekers*	Target customers valuing convenience over all other attributes	Own definition
Service-wrapped commodity	Distinguish commodity products by services that are added	Linder and Cantrell (2000)
Servitization of products	Sell ongoing services in addition to the product or even sell the service the product performs rather than the product	Johnson (2010)
Shared infrastructure	Share a common infrastructure among several competitors	Weill and Vitale (2001)
Shop*	Offer your value proposition with a shop	Own definition
Shop-in-shop	Build a store within another store	Gassmann et al. (2014)
Software firms	Create software and license/ sell it	Applegate (2001)
Solution provider	Provide a full range of services in one domain directly and via allies and attempt to own the primary consumer relationship	Gassmann et al. (2014), Linder and Cantrell (2000), Weill and Vitale (2001)
Subscription	Continuously provide customers with products or services and regularly charge upfront fees	Gassmann et al. (2014), Hanson and Kalyanam (2007), Johnson (2010), Rappa (2001), Tuff and Wunker (2010)
Supermarket	Offer a large variety of products at a low price	Gassmann et al. (2014), Linder and Cantrell (2000)
Supply chain management	Connect suppliers and distribution channels more closely	Strauss and Frost (2016)
Target the poor	Focus on the bottom-tier clients of the income pyramid and sell a large number of cheap products with low margin	Gassmann et al. (2014)
Transaction service and exchange intermediation	Provide integrated portal to coordinate complex transactions among involved several parties for spot markets	Hartmann et al. (2016), Linder and Cantrell (2000)
Trash-to-cash	Reuse already used products	Gassmann et al. (2014)
Trust intermediary	Provide a third-party payment mechanism for buyers and sellers to settle a transaction	Hartmann et al. (2016), Rappa (2001)
Trust services	Establish membership associations that abide by an explicit code of conduct, and in which members pay a subscription fee	Rappa (2001)
Trusted product leadership	Develop long-lasting product platform architectures to create a non-disruptive product upgrade path for locked-in customers	Linder and Cantrell (2000)
Ultimate luxury	Focus on selling to the top-tier customers of the income pyramid	Gassmann et al. (2014)
Under the umbrella pricing	Under-price the market leader and use marketing to convince customers your offerings are equivalent, fast follow in product/ service development	Linder and Cantrell (2000)
Usage fee*	Customers' payments depend on a certain variable of the usage	Own definition
User designed	Customers invent products that afterwards are produced by the company	Gassmann et al. (2014)
Value chain integrator	Coordinate activities across the value net by gathering, synthesizing, and distributing information	Timmers (1998), Weill and Vitale (2001)
		Gassmann et al. (2014), Timmers (1998)

Table 2 (continued)

Pattern	Definition	References
Value chain service provider	Only support parts of the value chain such as logistics or payments – but for several companies	
Value network*	Change your value network or the way you interact with it	Own definition
Value proposition development*	Develop your offering in a certain way	Own definition
Value proposition*	Offer certain products or services, or offer them in a certain way	Own definition
Value-added reseller	Sell a comprehensive range of undifferentiated products based on value-added services, e.g., through consultative selling, product availability, service, and promotional pricing	Linder and Cantrell (2000)
Vertical portals	Create a portal that specializes in a particular area and provides very deep content and functionality in this area	Applegate (2001), Clemons (2009)

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Appendix B. Does Business Model Matter for Startup Success? A Quantitative Analysis (P2)

DOES BUSINESS MODEL MATTER FOR STARTUP SUCCESS? A QUANTITATIVE ANALYSIS

Research in Progress

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Abstract

In multiple research areas, scholars try to find determinants for business performance. Especially for entrepreneurship, this is of interest as failure rates are high. Qualitative research demonstrates that a firm's business model influences its performance. However, research lacks large-scale quantitative studies to analyze if a firm's applied business model explains heterogeneity in business performance. Therefore, this research builds on a dataset of 500 startups and analyzes the relationship of their applied business model patterns and their business performance (i.e., survival as proxy). Two business model patterns are significantly correlated with a higher survival rate (i.e., Freemium and Subscription), while four patterns are significantly correlated with a lower survival rate (i.e., Cross Selling, Hidden Revenue, Layer Player, and No Frills). For literature, we enrich qualitative research with statistical evidence that business models matter for business performance and strengthen the concept's role as a useful theoretical construct in management and entrepreneurship research. For practice, the paper reinforces the importance of business models for startup success and provides clear guidance regarding which business model pattern increases the probability of startup survival. Findings provide first insights in the relationship of business models and business performance and opens up fruitful areas for future research.

Keywords: Business Model, Startup, Performance, Quantitative Research

1 Introduction

Startup firms are a driver of economic growth, innovation, and employment opportunities (Yankov, 2012). However, the majority of startups fail, with estimates ranging from 50% to 83% and up to 90% (Laitinen, 1992; Wetter and Wennberg, 2009; Krishna, Agrawal, and Choudhary, 2016). Management and entrepreneurship scholars have discussed various explanations. Krishna et al. (Krishna et al., 2016) explain firm performance mostly with financial factors, such as the amount of funding received. Cressy (2006) identifies trading losses, bad luck, and entrepreneurial talent as decisive factors for success. Strotmann (2007) detects talent, *"entry-mistakes,"* and industry-specific conditions as aspects that affect the success of startups. Nevertheless, the question on why some startups fail while others succeed remains as one of the central questions across research communities (Cooper, 1993; Spiegel et al., 2015).

In business model research, a discussion on the correlation between business models and enterprise performance has emerged (Zott, Amit and Massa, 2011; Lambert and Davidson, 2013; Foss and Saebi, 2017; Massa, Tucci and Afuah, 2017) and shows that business models are important for competitiveness and can create a new factor of innovation.

However, a large portion of business model research is qualitative in nature and highly contextual (Lambert and Davidson, 2013; Demil, Lecocq, Ricart and Zott, 2015; Spiegel et al., 2015). Many papers use case studies in specific industries, ventures, or regions, what limits their generalizability (Demil et al., 2015; Hermes, Böhm and Krcmar, 2019). Questions about the relationship of the firm's business model and its performance remain unanswered, for theory and for practice. Hence, there is a need for more quantitative research (Lussier and Pfeifer, 2001; Al-Debei and Avison, 2010; Zott et al., 2011), especially with a holistic understanding of business models and an industry-independent focus (Lambert and Davidson, 2013; Foss and Saebi, 2017). In this way, business models can become a comparable influencing factor for business performance (Demil et al., 2015).

Summarizing, neither entrepreneurship research nor business model research provides evidence for a correlation of certain business models and business performance (Al-Debei and Avison, 2010; George and Bock, 2011; Lambert and Davidson, 2013; Spiegel et al., 2015). The business model concept is a commonly used tool in practice. Business model patterns allow measuring this concept and provide direct implications for startups. Therefore, this paper investigates the statistical relationship between a startup's business model patterns and its performance. We address the following research question.

RQ: How important are business model patterns for explaining the heterogeneity in startup success?

This paper presents a statistical analysis about how startup success correlates with the applied business model patterns and identifies business model patterns that correlate with higher or lower success. We derive our hypothesis according to the influence of applied business model patterns on the chances of survival for startups. We test this hypothesis using a dataset of 500 startups, with each startup coded according to the 55 business model patterns defined by Gassmann et al., (Gassmann, Frankenberger and Csik, 2013) We apply contingency analysis and find evidence for our hypothesis. Results reveal two business model patterns significantly correlating with a higher startup survival and four patterns significantly correlating with lower startup survival. Thus, the business model matters for business performance. This underlines its role as a useful theoretical construct in management and entrepreneurship research. For startups, the paper emphasizes the importance of business models for startup success and provides clear guidance concerning which business model pattern might support success.

2 Related Work

In the last two decades, business model research evolved rapidly, resulting in a large body of research aiming to explore and explain the concept of business models and its practical implications (Zott et al., 2011; Foss and Saebi, 2017; Massa et al., 2017). Still, scholars do not agree on one common understanding and definition of a *"business model."* Massa et al. (2017) categorize existing definitions as: *"(1) business models as attributes of real firms having a direct real impact on business operations, (2) business models as cognitive/linguistic schema, and (3) business models as formal conceptual representations/descriptions of how an organization functions."* This paper uses the business model as a formal conceptual representation (Massa et al., 2017). Hence, a business model *"describes the design or architecture of the value creation, delivery, and capture mechanisms"* (Teece, 2010). Business models can be composed of multiple business model patterns (Osterwalder and Pigneur, 2010; Gassmann et al., 2013). Business model patterns are *"business models with similar characteristics, similar arrangements of business model Building Blocks, or similar behaviors"* (Osterwalder and Pigneur, 2010) that have been successful in the past (Gassmann et al., 2013) and are applicable in other contexts (Amshoff, Dülme, Echterfeld and Gausemeier, 2015; Weking, Hein, Böhm and Krcmar, 2018).

That business modes affect firm performance can be derived from the resource-based view (RBV) and the related theory of dynamic capabilities (Teece, 2007). The business model itself can be seen as a unique resource for competitive advantage (Barney, 1991), at least for a period of time since it can eventually be imitated (Teece, 2018). However, it influences and shapes dynamic capabilities, which can ensure sustainable competitive advantage (Teece, 2018). Thus, business models can impact firm performance.

Several studies support this hypothesis. The effects of business models on firm performance has emerged as one research stream (Zott et al., 2011; Osterwalder and Pigneur, 2012; Foss and Saebi, 2017; Massa et al., 2017). The concept of business models is relevant for firm performance (Shafer, Smith and Linder, 2005; Al-Debei and Avison, 2010; Rietveld, 2017). Afuah and Tucci (2001) even claim it is one of three determinants of performance. From a strategy perspective, the business model plays a crucial role in strategic planning in a rapidly changing macro-economy and can increase returns (Massa et al., 2017). Shafer et al. (2005) point out that no guarantees can be given solely by the business model. But, it forces to question strategic options, thereby increasing the chances of long-term success. One aspect is the idea that firms differentiate and, therefore, compete through their business model (Casadesus-Masanell and Ricart, 2010) and not through products or processes (Gassmann et al., 2013). Here the business model itself is a source for competitive advantage (Afuah and Tucci, 2001; Markides and Charitou, 2004). Another root of firm performance is the *"ability to both create and capture value"* (Shafer et al., 2005), which are both covered in the business model concept (Osterwalder, Pigneur, and Tucci, 2005). A firm may be superior in creating value by applying a unique business model (Morris, Schindehutte and Allen, 2005). Chesbrough (2010) claims that the business model is more significant for value creation than the product itself. Thus, great innovations fail if the business model is not designed properly (Teece, 2010). Executive research finds that business model innovation leads to higher profitability than product or process innovation and highly innovative firms do innovate their business models (Boston Consulting Group, 2009). Firms that innovate their business models are more likely to outperform their markets (IBM Corporation, 2012).

Summarizing, most business model research is of a qualitative nature (Lambert and Davidson, 2013; Demil et al., 2015; Spiegel et al., 2015). To make business models comparable with other performance indicators (Demil et al., 2015), quantitative research on business models and firm performance is needed (Lussier and Pfeifer, 2001; Al-Debei and Avison, 2010; Zott et al., 2011; Foss and Saebi, 2017), especially with a holistic, industry-independent focus (Lambert and Davidson, 2013).

Our quantitative analysis of business models as performance indicators takes place in an entrepreneurship context because startups show an enormous failure rate (Laitinen, 1992; Wetter and Wennberg, 2009; Krishna et al., 2016). The influencing factors of startup success or failure remain a central question in research (Cooper, 1993; Spiegel et al., 2015). This research focuses on the mere survival of a startup as the essential metric of startup success.

The survival of a startup is ultimately determined by its ability to cover all its costs. In accordance with other qualitative research on business models, Morris et al. (2005) argue based on Schumpeter (1936) that an effective business model is responsible for superior returns. Further, the returns of the same product vary based on the business model (Chesbrough, 2010). Thus, we argue that some business model patterns enable firms to generate higher turnover or at least generate sufficient turnover faster so that a startup can survive. Thus, we propose our hypothesis as follows.

Hypothesis: *Applied business model patterns influence the chances of survival for startups.*

Existing qualitative research already investigated on the correlation between business model and firm performance. In two papers, Zott and Amit (2007a, 2007b) reveal that some business models, if novelty-centered, outperform others. If the business model is based on increasing efficiency, then it may be influential on firm performance. By finding proof for the interaction with a firm's product market strategy, they show that business models do have an impact on distinct entrepreneurial aspects, thus influencing a firm's market value. Malone et al. (2006) analyze all publicly traded US firms between 1998 and 2002 and find that some business models perform better than others. Kraus et al. (2017) at-test this relation for *"born-global"* startups, using quantitative surveys and qualitative interviews with 252 founders. Spiegel et al. (2015) conclude that socially well-connected founders are more successful because their networks help them develop the right business model. In contrast, Camison and Villar-López (2010) find *"no significant differences in performance between the different business models."* Some scholars used a cluster analysis or very general business models before investigating the dependent success variable (Malone et al., 2006; Böhm et al., 2017) while others focused on specific aspects of the business model (Zott and Amit, 2007a, 2007b; Spiegel et al., 2015) or on very specific firms (Camison and Villar-López, 2010; Kraus et al., 2017). Even though these studies already improve the understanding of performance implications caused by the applied business model, none uses a holistic understanding of business models, such as business model patterns, and provides a large-scale analysis. This paper provides the first large-scale empirical research based on startups and business model patterns. Our research is a general analysis that provides insights on specific business model patterns, targeting the question if any explicit business model patterns result in higher or lower chances of startup success.

3 Dataset and Research Method

The dataset contains 500 startups from Crunchbase (www.crunchbase.com). All firms were founded in 2015 and were randomly selected so that 250 of the firms were still operating and 250 had failed. This sampling reduces the success bias of the self-reported database (Antretter, Blohm and Grichnik, 2018). For each startup, we coded 55 binary variables that describe whether a startup applies a business model pattern (1) or not (0). This results in a vector as illustrated in Table 1.

BMP	1	2	3	4	5	…	50	51	52	53	54	55
Appl.	1	1	0	0	0	…	1	0	0	1	1	0

Table 1. Example vector of a startup's applied business model patterns

Two persons coded the applied business model patterns and consolidated their results in regular meetings to ensure intercoder reliability. As an objective proxy for startup success, we use the binary variable operating (1 = still operating and 0 = failed). We scanned the firms' webpages in addition to the Crunchbase website for data triangulation. The dataset was created by the end of 2017. Thus, we can evaluate startups and their business model after two years of operation and avoid coding initial business models that startups do not follow anymore.

To test the hypothesis (whether the applied business model pattern has an impact on the survival of a startup), we chose the contingency analysis, which provides a way to discover correlations between two nominally scaled variables (Backhaus, Erichson, Plinke, and Weiber, 2015). The scale level of the independent variable (the applied business model pattern) is nominal and the dependent variable for the hypothesis (survival of the firm) is on a nominal scale as well. We used the programming language R and the IDE RStudio. For each pattern, we created a contingency table with the application variable and the success variable as illustrated in Table 2. These tables were analyzed as to whether a correlation exists.

	Success	
Two-Sided Market	**0**	**1**
0	166	194
1	83	55

Table 2. Example of a Contingency Table (Pattern: Two-Sided Market)

If an expected frequency in a contingency table was below five, we did not include the business model pattern in our further analysis as suggested for chi-squared tests (Backhaus et al., 2015). Based on the percentage of success or failure if a business model pattern was applied, we drew an interpretation whether a correlation may exist. We assumed no correlation if the difference between success and failure was below 20%. Next, we performed a chi-squared test to determine the randomness of the correlations and their respective strength. The randomness could be disproved if the *p*-value was below 0.05 (Backhaus et al., 2015). As Backhaus et al. (2015) suggest to perform the exact Fisher test for samples with $n < 20$, we used this test to reassure the results of the chi-squared test. Finally, the phi-coefficient (φ) was calculated to investigate the strength of the correlations.

4 Results

Business Model Pattern	***n***	**Fisher *p*-Value**	**Chi² *p*-Value**	**Phi-Coefficient (φ)**
Addon⁺	492	0.08740	0.140100	−0.08
Cross Selling* **	500	0.00043	0.000956	−0.16
Crowd-Sourcing*	498	0.01705	0.020270	−0.11
Customer Loyalty**	495	0.00717	0.021440	−0.12
Freemium*	419	0.01208	0.018610	0.12
Hidden Revenue**	427	0.00219	0.002843	−0.15
Ingredient Branding*	496	0.00345	0.011800	−0.13
Layer Player**	492	0.00119	0.001620	−0.15
Leverage Customer Data**	486	0.00356	0.004850	−0.14
Long Tail*	498	0.02026	0.025340	−0.11
No Frills***	497	0.00028	0.000603	−0.16
Rent Instead of Buy⁺	498	0.05349	0.088950	−0.09
Subscription***	450	0.00001	0.000029	0.27
Two-Sided Market**	498	0.00675	0.006866	−0.13
Ultimate Luxury⁺	499	0.09029	0.136500	−0.08

⁺$P < 0.10$; *$P < 0.05$; **$P < 0.01$; ***$P < 0.001$

Table 3. Results of the Contingency Analysis

Table 3 shows the results of our analysis. The table includes the business model patterns that passed all prior sorting only, thus all are significant. The phi-coefficient indicated toward firm success for the business model patterns *Freemium* and *Subscription*. The pattern *Subscription* shows with φ = 0.27 by far the strongest correlation in our results. For the *Freemium* pattern φ is 0.12, which is statistically not indicating a non-trivial strength of the correlation (Backhaus et al., 2015). Still it shows an indication towards an increased survival rate. We further include four business model patterns in our discussion that indicate a worse survival rate. We focus on patters with the strongest effect size (i.e., φ ≤ -0.15): *Cross Selling*, *Hidden Revenue*, *Layer Player* and *No Frills*. Table 4 summarizes the results and defines the relevant business model patterns.

Business Model Pattern	**Definition (Gassmann et al., 2013)**	**Survival Rate**
Subscription	The customer pays a regular fee, typically on a monthly or an annual basis, in order to gain access to a product or service.	increase
Freemium	The basic version of an offering is given away for free in the hope of eventually persuading the customers to pay for the premium version.	increase
Cross Selling	Services or products from a formerly excluded industry are added to the offerings, thus leveraging existing key skills and resources.	decrease
Hidden Revenue	The main source of revenue comes from a third party, which cross-finances whatever free or low-priced offering attracts the users.	decrease
Layer Player	A layer player is a specialized company limited to the provision of one value-adding step for different value chains.	decrease
No Frills	Value creation focuses on what is necessary to deliver the core value proposition of a product or service, typically as basic as possible.	decrease

Table 4. Definitions of Business Model Patterns

5 Discussion

Why many startups fail (50–90 %) while others succeed and grow exponentially remains an important topic for research and practice (Cooper, 1993; Spiegel et al., 2015). Business model research shows that a firm's business model influences its performance (Zott et al., 2011; Lambert and Davidson, 2013; Foss and Saebi, 2017; Massa et al., 2017). However, research lacks large-scale quantitative studies to demonstrate if applied business models explain heterogeneity in business performance. In this paper, we analyze a dataset of 500 startups according to the relationship of their applied business model patterns (Gassmann et al., 2013) and their business performance (i.e., survival as proxy).

The contingency analysis revealed a significant correlation between the applied business model pattern and startup survival for 15 out of 55 business model patterns. We discuss six patterns in the following and focus on the ones with the strongest effect size. Two of these 15 business model patterns point toward higher chances of survival, namely, *Freemium* and *Subscription* ($\varphi \geq 0.12$). The *Freemium* pattern leads to higher chances of survival. Related works, such as Liu, Au, and Choi (2014) analyzed *Freemium* apps in the Google Play Store. Paid mobile apps showed increased sales volume if there is an additional free version of the app. Similarly, Bawa and Shoemaker (2004) showed that free samples create increased sales for the paid product. Both studies indicate higher sales measures for tangible products as well as mobile apps with a *Freemium* business model. This paper underlines these results by revealing that *Freemium* also contributes to the survival of startups. As the critical point for young firms is to be recognized by customers, sell their first product(s), and become established in the market, without sales or positive growth rate, they will struggle to receive needed funding or even to reach break-even (Böhm et al., 2019). Second, the *Subscription* pattern additionally indicates higher survival rates. In the software industry, *"the subscription model helps the vendor lock in consumers so as to increase profit when there is great uncertainty associated with the next version software"* (Zhang and Seidmann, 2010). Because startups typically deal with uncertainty in various domains, including the development of their product or service, this effect may be applicable in this context. Moreover, the subscription model aims at continuous revenue streams. This additionally supports survival and a stable base for further growth. In this paper, we underline these findings and see that subscription as well contributes to higher survival rates of startups.

In contrast, the analysis showed a higher failure rate for startups applying the patterns *Cross Selling*, *Hidden Revenue*, *Layer Player*, and *No Frills* ($\varphi \leq -0.15$). First, *Cross Selling* leverages an existing customer base and therefore is difficult to apply in early stages of firms. This might lead to lower chances of survival when applied. Second, *Hidden Revenue* typically builds on advertising as revenue stream (Gassmann et al., 2013). However, advertising as revenue stream has various disadvantages

(Clemons, 2009) and is difficult to establish in early stages without strong customer base. This might explain the negative influence on survival rates. Third, for applying *Layer Player* a startup would need access to different value-chains and specialize on one value adding step. This problem of access might lead to lower survival rates. Additionally, a few big players often dominate these single steps, such as PayPal. Fourth, with *No Frills* firm follow a low-price strategy and gain revenues with selling additional services. However, this requires financial resources to enable selling with a negative ratio, what is problematic for startups and explains the pattern's negative impact on survival.

5.1 Contributions to Research

This study contributes to two literature streams. First, the results contribute to strategy and business model literature. We support the understanding of business models as unique resources (Barney, 1991; Teece, 2018). The findings add quantitative support to the current qualitative research on implications of business models on performance (Shafer et al., 2005; Al-Debei and Avison, 2010; Rietveld, 2017); Afuah and Tucci, 2001). This research provides evidence that a startup's chances of survival are associated with its business model. It shows that some business models perform better than others do. We find quantitative and empirical support for the theory that firms differentiate and compete through their business model (Casadesus-Masanell and Ricart, 2010) and not only through products or processes (Gassmann et al., 2013). A firm's business model can support competitive advantage (Afuah and Tucci, 2001; Markides and Charitou, 2004). *Freemium* and *Subscription* ensure startup survival. The results address several calls for research in the business model literature. We provide quantitative research on business model success (Lussier and Pfeifer, 2001; Al-Debei and Avison, 2010; Zott et al., 2011; Foss and Saebi, 2017). The results especially show a holistic, industry-independent focus on the relationship between business model and firm performance (Lambert and Davidson, 2013). Moreover, results extend quantitative business model research, e.g., Zott and Amit (2007a, 2007b) and Malone et al. (2006), by identifying two explicit business model patterns that demonstrate higher chances for startup survival and four patterns that indicate lower chances for startup survival. Overall, the findings demonstrate that the business model influences business performance. This contributes to our understanding of the impact of business models and underlines that the business model is a useful theoretical construct in management research (Massa et al., 2017).

Second, the results advance entrepreneurship research by providing new insights on how to explain heterogeneity in startup survival. The paper shows that a startup's applied business model can partly explain its survival. The results reveal that the business model is relevant and a new influencing variable for startup performance. In addition, findings show certain business model patterns that are more likely to result in a startup's survival (i.e., *Freemium* and *Subscription*) and failure of a startup (i.e., *Cross Selling*, *Hidden Revenue*, *Layer Player*, and *No Frills*). Overall, the findings contribute to explaining startup performance and, thus, advance entrepreneurship literature.

To the best of our knowledge, we conduct the first large-scale empirical research based on business model patterns and startups. Our research provides a general analysis on the question if certain business model patterns result in higher chances of success and, hence, contributes to business model, strategy, and entrepreneurship research.

5.2 Contributions for Practice

For practice, the results provide a starting point for entrepreneurs supporting their business model design. First, the findings indicate that the business model does influence startup success. This gives business model decisions a new level of importance for entrepreneurs. Second, the paper indicates practical guidance on which business model pattern entrepreneurs may focus to increase their chances of success. We discovered business model patterns that increase the chances for survival (i.e., *Freemium* and *Subscription*) as well as patterns that decrease it (i.e., *Cross Selling*, *Hidden Revenue*, *Layer Player*, and *No Frills*). Hence, the findings provide clear and straightforward support for startups' fundamental decisions concerning the business model.

5.3 Limitations

This study has some limitations. First, we agree with the remarks emphasized by Brea-Solís et al. (2014), Rietveld (2017), and Teece (2010) that there is no *one* successful business model. Moreover, Weill, Malone, and Apel (2011) found that the business model preferred by investors varies from time to time. Second, the analysis explaining startup survival does not show a strong effect size. This might be because there are many other influencing factors we did not control for yet, such as factors related to individual entrepreneurs, e.g., personality, experience, education, bad luck, and entrepreneurial talent, organizational factors, e.g., legal form, team size, industry, and the funding or self-financing, and environmental factors, e.g., markets, competition, workforce quality, region, and sector-specific conditions (Cressy, 2006; Strotmann, 2007; Krishna et al., 2016; Antretter et al., 2018). Nevertheless, we found two business model patterns with significantly lower failure rates and four patterns with significantly higher failure rates indicating rather successful and rather not successful patterns.

6 Conclusion and Future Research

Research still lacks clear determinants for business performance, in particular in entrepreneurship (Cooper, 1993; Spiegel et al., 2015). Research qualitatively shows that business models matter for firm performance (Zott et al., 2011; Lambert and Davidson, 2013; Foss and Saebi, 2017; Massa et al., 2017). However, neither entrepreneurship research nor business model research proofs the relationship of business models and business performance quantitatively (Al-Debei and Avison, 2010; George and Bock, 2011; Lambert and Davidson, 2013; Spiegel et al., 2015). Hence, we analyze this relationship with a dataset of 500 startups building on business model patterns (Gassmann et al., 2013) and startup survival as proxy for success. We find a significant relationship for 15 out of 55 business model patterns. Two indicate higher chances of survival (i.e., *Freemium* and *Subscription*), whereas four point toward lower chances of survival (i.e., *Cross Selling*, *Hidden Revenue*, *Layer Player*, and *No Frills*).

This research contributes to strategy, business model, and entrepreneurship research. To the best of our knowledge, this is the first large-scale quantitative-empirical study using startups and business model patterns. For practice, results provide decision support for entrepreneurs and strategy development. However, small effect sizes indicate the early state of this study and opens up avenues for future research. To clearly separate the influence of the business model, moderating and controlling variables are needed. Future research can consider markets, regions and industries since they can affect startup success (Strotmann, 2007). Further research can consider moderating constructs, such as funding, investors, or digital traces (Antretter et al., 2018). Moreover, similar analyses can consider established firms to investigate emerging business models such as multi-sided platforms (Hein et al., 2018, 2019) or transformations in traditional industries (Weking, Brosig, et al., 2018; Weking, Stöcker, et al., 2018). Concluding, the research at hand provides first significant results for the relationship of business models and business performance and opens fruitful avenues for further research.

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Appendix C. Archetypes for Industry 4.0 Business Model Innovations (P3)

Archetypes for Industry 4.0 Business Model Innovations

Completed Research

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Abstract

Industry 4.0 (I4.0) also known as the fourth industrial revolution has emerged for describing the digitalization of manufacturing industries. In practice, the transition to I4.0 is crucial for manufacturing firms to sustain competitive advantage and seize new opportunities. Most research focuses on the technological aspects of I4.0 in form of product and process innovations. Despite I4.0's rising attention among both researchers and practitioners, there exists only little research about I4.0 business model innovation (BMI), even though business model (BM) innovators can be more successful than product or process innovators. To address this research gap, we analyze 15 case studies of I4.0 BM innovators. We develop a taxonomy to characterize I4.0 BMs and derive 13 archetypes of I4.0 BMIs that describe transitions towards I4.0 BMs. The three identified super-archetypes are integration, servitization and expertise as a service. Our study deepens the understanding and structure of I4.0 BMs and I4.0 BMIs.

Keywords

Business model innovation, Industry 4.0, Industrie 4.0, Taxonomy, Archetypes, Case study.

Introduction

Gearing traditional industries towards the opportunities and challenges of digitization is frequently discussed among researchers and practitioners around the globe. Initiatives such as "Advanced Manufacturing Partnership" in the United States, "La Nouvelle France Industrielle" in France, "Future of Manufacturing" in the United Kingdom, "Made in China 2025" alongside the "Internet Plus" in China, and "Industry 4.0" in Germany address the convergence of "classic" industrial production with IT and new technologies, e.g. Internet of Things (Hermann et al. 2016; Liao et al. 2017; Ramsauer 2013). Innovating traditional industries is an indispensable prerequisite for securing competitiveness and economic wealth of the industrial nations in the long run (Ramsauer 2013).

Even though studies show that not only product and process but also business model innovations (BMI) are essential for future success (Wischmann et al. 2015), both researchers and practitioners mainly focus on the technological implications of Industry 4.0 (I4.0) (Burmeister et al. 2016; Demont and Paulus-Rohmer 2017; Kiel et al. 2016; Leyh et al. 2017; Leyh et al. 2016). Additionally, studies show that business model (BM) innovators are more successful than pure product or process innovators (Gassmann et al. 2013). Often, the provider with the best BM dominates the market and not providers of leading technological solutions (Chesbrough 2010).

Studies have recognized a lack of research about BMI in the context of I4.0. They address different aspects of it. Some authors investigate the BM components that are affected most by I4.0 (Arnold et al. 2016; Becker et al. 2017; Kiel et al. 2016). Others explore specific tools usable for I4.0 BMI (Burmeister et al. 2016). Some provide a specific process model to guide I4.0 BMI (Demont and Paulus-Rohmer 2017; Kaufmann 2015). However, these studies remain abstract and focus the transformation process. To the best of our knowledge, no study has analyzed case studies of I4.0 BM innovators to derive a taxonomy of I4.0 BMs or archetypes of I4.0 BMI. Though recent studies provide domain-specific taxonomies for superordinate concepts of I4.0, such as digital BMs (Bock and Wiener 2017; Remane et al. 2017b) or data-driven BMs (Hartmann et al. 2016), or for particular subtypes of I4.0, such as platform BMs (Täuscher and Laudien 2017), cloud BMs (Labes et al. 2013) or car sharing BMs (Remane et al. 2016). These taxonomies are either too general or too specific to classify I4.0 BMs.

Concluding, extant literature provides only little conceptual guidance regarding the questions: What characterizes Industry 3.0 (I3.0) and I4.0 BMs? How to classify I4.0 BMs? Which I4.0 BMI archetypes exist? These questions, however, are important for manufacturing firms to remain competitive and seize upcoming opportunities (Kiel et al. 2016; Ramsauer 2013).

In order to bridge gap, this article creates a taxonomy for I4.0 BMs and 13 I4.0 BMI archetypes. The remaining paper is structured as follows: In the next section, we outline the theoretical background about BMs, BMI and I4.0. Subsequently, we present a three-step research approach that consists of i) creating a case base of I4.0 BMI cases, ii) developing a taxonomy based on the identified cases and extant literature, and iii) empirically deriving I4.0 BMI archetypes by applying the taxonomy to the cases. Finally, we discuss our findings focusing on the strategic use of IT before we conclude our research.

Theoretical Background

Despite a large amount of research about *BMs*, no commonly accepted definition has been established so far (Foss and Saebi 2017; Schneider and Spieth 2013). Literature, however, converges on the components of BMs, although using different terminology. These components are value proposition, market segments, structure of the value chain, value capture mechanisms and "how these elements are linked together in an architecture" (Saebi et al. 2016). Most current definitions of a BM are similar or consistent with Teece (2010) definition (Foss and Saebi 2017): A BM is "the design or architecture of the value creation, delivery, and capture mechanisms it employs" (Teece 2010) and "how the enterprise creates and delivers value to customers, and then converts payments received to profits" (Teece 2010).

BMI represents a research stream of BM literature that recognizes the BM as a potential source of innovation next to product, service, process and organizational innovation (Foss and Saebi 2017; Zott et al. 2011). Despite rising attention for BMI in literature and practice (Schneider and Spieth 2013; Wirtz et al. 2016), research about the concept is still immature (Foss and Saebi 2017; Schneider and Spieth 2013; Spieth et al. 2014; Wirtz et al. 2016). BMIs "are designed, novel, nontrivial changes to the key elements of a firm's business model and/or the architecture linking these elements" (Foss and Saebi 2017). So, "designed" implies that BMI is a deliberate process requiring top-management support. The claim for "novel, non-trivial changes" excludes minor adaptions of the existing BM, e.g. adding a new supplier.

The term *"Industry 4.0"* and the German version *"Industrie 4.0"* describe the digital transformation and a new manufacturing paradigm for traditional industries. The German government announced its eponymous high-tech initiative "Industrie 4.0" in 2011. However, there is no consensual definition about the term I4.0 and the dissociation of its predecessor I3.0 (Hermann et al. 2016; Pereira and Romero 2017). Literature does not agree if the term I4.0 denotes the transformation process or its outcome. Some authors define I4.0 as (i) the process "towards the increasing digitization and automation of manufacturing industry" (Brettel et al. 2014; Oesterreich and Teuteberg 2016), some as (ii) a new stage or paradigm for industrial production (Kagermann et al. 2013; Pereira and Romero 2017), i.e. the outcome of the process. Other authors use I4.0 as (iii) an umbrella term for new technologies and concepts (Hermann et al. 2016; Pfohl et al. 2015). We follow the outcome perspective and understand I4.0 as the fourth stage of industrial production. After steam power enabled mechanical production at the end of the 18th century (*Industry 1.0*), the intensive use of electrical power and assembly lines enabled mass production at the end of the 19th century (*Industry 2.0*). The use of IT and electronics enabled automated production at the second half of the 20th century (*I3.0*). Cyber-physical systems (CPS) and Internet of

Things (IoT) enable smart production nowadays (*I4.0*). CPS and IoT integrated in manufacturing enable smart processes, products, machines, systems and factories (Hermann et al. 2016). Elements can independently communicate and exchange information with each other, trigger and control the next actions, and steer the production (Pereira and Romero 2017; Ramsauer 2013). This results in a *smart factory* with "sensors, actors and autonomous systems" (Lasi et al. 2014). The factory can "context-aware assist people and machines in execution of their tasks" (Hermann et al. 2016) by drawing on information of the physical and virtual world. Additional key concepts of I4.0 are vertical and horizontal end-to-end integration. Horizontal integration combines resources, processes and IS intra- and inter-organizationally, across the entire value chain. Vertical integration refers to data sources within an organization (Kagermann et al. 2013).

Methodology

We divided our research approach in three sections. First, we searched for existing case studies about BMI in the context of I4.0 and set up a case base. Second, we developed a taxonomy of I4.0 BMs. Third, we derived I4.0 BMI archetypes of transitions from I3.0 to I4.0 BMs.

1) Creating a case base

We searched the scientific databases EBSCO, ScienceDirect, Scopus, IEEE Explore, and Web of Science for journals, books, conference papers and teaching cases, as well as Google Search for case studies about BMI in the context of I4.0. Moreover, we considered practice reports (e.g. McKinsey, BCG, Accenture, Microsoft), and case studies about the Industrial IoT and data driving BMI that fit to the I4.0 definition from above. If several authors mentioned a case, we combined it to avoid double counting and gain a more holistic case description. We got an initial set of 40 use cases. To augment case data and to support data triangulation (Yin 2014), we manually searched for the case studies' BMs on the firm websites and publically available press releases. We gathered all information in a case base (Yin 2014). Finally, we checked all 40 initial cases for i) sufficient information of its BM and BMI, and ii) fit to the BMI definition from above. This resulted in 15 cases for further consideration: Ten cases explicitly labeled as I4.0 case and five cases mentioned in I4.0 related areas that meet the I4.0 definition (see Table 1).

Iteration	Firm	Main empirical study	Analyzed sources
2nd Iteration: 10 cases explicitly labeled as I4.0 BMI	Atomic	Lassnig et al. (2017)	5
	AVL	Lassnig et al. (2017)	4
	Claas – 365Farmnet	Bauernhansl et al. (2015)	7
	eMachineshop	Bauernhansl et al. (2015)	4
	Kaeser Compressors	Kaufmann (2015)	6
	Konecranes	Wortmann et al. (2017)	5
	Local Motors	Bauernhansl et al. (2015)	7
	Shapeways	Bauernhansl et al. (2015)	5
	TRUMPF - AXOOM	Grünert and Sejdić (2017)	7
	Zumtobel	Lassnig et al. (2017)	4
3rd Iteration: 5 cases from related topics fitting to the I4.0 definition	Adidas	Plattform-i40 (2017)	11
	Caterpillar	Schaefer et al. (2017)	5
	GE Digital	Schaefer et al. (2017)	7
	Ponoko	Gassmann et al. (2013)	4
	Texa CARe	Microsoft (2017)	4

Table 1. Case Studies

2) Developing a taxonomy

We applied Nickerson et al. (2013) methodology to systematically develop a taxonomy for I4.0 BMs. The method allows us to combine theoretical findings of BMs with empirical findings of case studies (Remane et al. 2016). Following Nickerson et al. (2013), we applied a two-step approach.

First, we specified meta-characteristics that "serve as the basis for choice of characteristics in the taxonomy" (Nickerson et al. 2013) and the ending conditions for terminating the iterative approach. In accordance with Saebi et al. (2016), we chose the five generally accepted BM components *architecture*, *market segments*, *value proposition*, *value chain*, and *value capture* as meta-characteristics. Each dimension and characteristic of the taxonomy must relate to these characteristics. This helped us to systematically identify and organize relevant dimensions (Remane et al. 2016). We used the eight objective and five subjective ending conditions suggested by Nickerson et al. (2013) following the research design of Bock and Wiener (2017).

Second, we developed the taxonomy with three main iterations. In the first iteration, we conducted a conceptual-to-empirical approach by deriving dimensions and characteristics from literature to base our taxonomy on extant research. In the second iteration, we proceeded empirical-to-conceptual by applying the taxonomy resulting from the first iteration to the ten explicitly labeled I4.0 cases. We randomly chose a case and conducted a qualitative structured data analysis (Miles et al. 2013). Further, we manually coded the case description by using BM patterns (Remane et al. 2017a) and empirically derived characteristics from the specific case (within-case analysis). Afterwards, we classified the case within the taxonomy, and, if necessary, added further characteristics and dimensions to the taxonomy until we analyzed all cases of our case base. We dropped and synthesized characteristics and dimensions to keep the taxonomy lean without losing discriminative power. The third iteration also followed the empirical-to-conceptual approach. We manually coded the description of the five I4.0 related cases by using BM patterns (Remane et al. 2017a) and empirically derived characteristics (Miles et al. 2013). We classified each case with the taxonomy resulting from the second iteration. Here, we did not have to add, merge or split dimensions or characteristics. Further, the taxonomy met all other objective and subjective ending conditions. Thus, we terminated the taxonomy development process.

3) Deriving archetypes

In order to derive BMI archetypes, we first applied our taxonomy to all cases in form of a within-case analysis (Yin 2014) to identify transition archetypes from I3.0 to I4.0 BMs, i.e. I4.0 BMIs. We characterized the initial BM (I3.0) and the new BM (I4.0) of each case using the taxonomy. The taxonomy reveals for each case the changes resulting from the case's BMI. Second, we generalized from the case descriptions based on the taxonomy. We conducted a cross-case analysis (Yin 2014) in form of a qualitative cluster analysis. We identified three super-archetypes and ten related sub-archetypes with similar characteristics of the cases' BMI.

Results

Taxonomy

The derived taxonomy for I4.0 BMI consists of six meta-dimensions and 23 dimensions with two to six distinct characteristics each. The meta-dimensions reflect the BM as defined above, namely the linking architecture that relates the BM components: target customer, value proposition, value creation and value capture. In order to improve the structure, we split the component value creation into two meta-dimensions: *value chain* and *key elements*. The meta-dimension *architecture* refers to a firm's new BM. The remaining five meta-dimensions characterize both, I3.0 and I4.0 BMs. Table 2 shows the taxonomy.

Meta-dimensions	Dimensions	Characteristics						
Architecture	Organizational change	Product/service line extension	New product/ service line	New division	Spin-off			
	BM strategy	Add on	Lock-in	Aikido	Make more of it	Multi-sided market		
	Innovativeness	Evolution	New for company	New in industry				
Target customers (who)	Market	B2B	B2C	C2C				
	Customer segments	Existing customer segment	New customer segment	Multi-sided market				
	Customer contact	Intermediaries	Hybrid	Direct				
	Sales Channel	Offline	Bricks & clicks	Online				
Value proposition (what)	Product	Physical	Physical, digital charged	Digital	No			
	Service	No	Repair and maintenance	Remote usage and condition monitoring, predictive maintenance	Product	Production	IT	Advice & consultancy
	Value proposition	Working product at competitive price	Solution Provider	Guaranteed availability	Full service, full responsibility operator	Do more to address the job	Long tail	
Value chain (how)	Product design & development	Hired engineers/ experts	Customer (user designed)	Development community and crowd sourcing				
	Product customization	Custom-made (high cost)	Mass production	Mass customization	Mass individualization (low cost)			
	Push/ pull	Push/ make-to-stock	Pull/ on-demand					
	Facility location	Low-wage countries	Centralized	Global	Wage-independent	Decentralized	Local	

<table>
<tr><td></td><td>Role in value chain</td><td colspan="30">Orchestrator</td><td colspan="30">Integrator</td><td colspan="30">Service & support</td><td colspan="30">Intermediary</td></tr>
<tr><td rowspan="4">Key elements (how)</td><td>Key partners</td><td colspan="40">Traditional within-sector partnerships</td><td colspan="40">External individuals, businesses and research institutes (open BM)</td><td colspan="40">Customer</td></tr>
<tr><td>Analytics as a key activity</td><td colspan="40">No</td><td colspan="40">Internal product and process data</td><td colspan="40">Internal and customer’s product and process data</td></tr>
<tr><td>Human role</td><td colspan="24">Operating machines</td><td colspan="24">Onsite maintenance</td><td colspan="24">Remote monitoring & maintenance</td><td colspan="24">Software development & IT</td><td colspan="24">Consultant</td></tr>
<tr><td>Platform</td><td colspan="24">No</td><td colspan="24">Closed</td><td colspan="24">Trading</td><td colspan="24">Innovation</td><td colspan="24">Trading & innovation</td></tr>
<tr><td rowspan="4">Value capture (why)</td><td>Revenue model</td><td colspan="15">Sales</td><td colspan="15">Licensing</td><td colspan="15">Revenue sharing</td><td colspan="15">Freemium</td><td colspan="15">Physical Freemium</td><td colspan="15">Rent/ lease</td><td colspan="15">Usage based</td><td colspan="15">Subscription fee</td></tr>
<tr><td>Continuity</td><td colspan="40">1x</td><td colspan="40">Mixed</td><td colspan="40">Continuous</td></tr>
<tr><td>Sales model</td><td colspan="40">Ownership/ service delivery</td><td colspan="40">Use availability</td><td colspan="40">Result</td></tr>
<tr><td>Profit logic</td><td colspan="40">Reduce costs</td><td colspan="40">Increase revenue</td><td colspan="40">Both</td></tr>
</table>

Table 2. Taxonomy of Industry 4.0 Business Models

Archetypes

We identified three super-archetypes and ten sub-archetypes of I4.0 BMs using the taxonomy. The super-archetype *integration* innovates its BM around new processes, *servitization* around new products, and *expertise as a service* around a hybrid of products and processes. Table 3 gives an overview.

<table>
<tr><th>Super-archetypes</th><th colspan="12">Sub-archetypes</th></tr>
<tr><td>Integration</td><td colspan="4">Crowd sourced innovation</td><td colspan="4">Production as a service</td><td colspan="4">Mass customization</td></tr>
<tr><td>Servitization</td><td colspan="4">Life-long partnerships</td><td colspan="4">Product as a service</td><td colspan="4">Result as a service</td></tr>
<tr><td>Expertise as a service</td><td colspan="3">Product-related consulting</td><td colspan="3">Process-related consulting</td><td colspan="3">Broker platforms</td><td colspan="3">IoT platforms</td></tr>
</table>

Table 3. Archetypes of Industry 4.0 Business Model Innovations

Integration – Process-focused BMI

Integration covers BMIs starting from a value chain orchestrator to an *integrator*. An orchestrator is highly specialized on a single step of the value chain, whereas an integrator aims to cover the whole value chain (Remane et al. 2017a). The transition from I3.0 to I4.0 changes the meta-dimensions target customers and value chain. Concerning target customers, *integration* changes sales processes from indirect customer interaction via intermediaries (I3.0) to *direct* customer interaction via own *online shops* (I4.0). The direct online sales model complements the I3.0 solution or replaces it completely. Atomic, for example, sells ski via independent physical retail stores and its own online shop “customstudio”. In contrast, eMachineshop only uses its online shop. The value chain indicates most changes. Firms open their innovation processes by integrating *customers* and other *externals* in the product development. *Smart production* converts the production process from push to pull, and relocates factories from centralized production for a global market in low-wage countries to decentralized production close to the local markets even in high-wage countries. The super-archetype integration has three sub-archetypes: *crowd sourced innovation*, *production as a service*, and *mass customization*.

Crowd sourced innovation. A new product development and design process shapes this BMI. Firms move form a closed (I3.0) towards an *open business model* (I4.0). Using an *innovation platform* as a key resource enables them to integrate externals, individuals as well as businesses into product development. A community of people designs products (*crowd sourcing*) instead of only hired experts. The car manufacturer Local Motors, for example, announces challenges for car engineering on its innovation platform *Launch Forth* and members can hand in suggestions.

Production as a service. Transforming product ideas into physical goods is core to this sub-archetype. Firms of this type undertake the production from design checking until shipping for their customers. The value chain shifts from producing *custom-made*, *expert designed* goods (I3.0) to *mass individualized*, *user-designed* goods (I4.0). The *customer* becomes a *key partner* and can choose among a wide range of different materials and production techniques (*long tail*). The spin-off of Philips Electronics Shapeways.com, for example, is a platform for 3D-printed consumer goods. The firm offers a product printing service, an online shop and a designer community. Designers can upload their 3D design, select materials, and offer it to other members via the online shop. When receiving an order, Shapeways.com builds the product on-demand close to the final destination and ships it.

Mass customization. The integration of customers into the value chain characterizes this sub-archetype: a shift from mass production (I3.0) to *mass customization* (I4.0). Mass customization enables customers to adapt the final product to their individual taste by choosing among a range of options (*long tail*). Smart production enables economic production of small lot sizes, even lot size one. For example, Adidas' customers can personalize shoes in the online-shop, i.e. change the color or add individual letters or logos.

Servitization – Product-focused BMI

Integrating sensors in products (*digitally charged products*) enables the super-archetype *servitization* to provide new product service systems instead of selling only tangible products. Thus, new offerings rather than new processes are the basis for this BMI, steering customers I3.0 production towards smart production. The meta-dimension value chain does not change. Architecture and target customers undergo different shifts per sub-archetype. New key resources are a *closed IoT platform* and *analytics* of product and process data from the customers' sites. The human role evolves from an *onsite maintainer* (I3.0) into a *remote observer and maintainer* (I4.0). Long-ranging service contracts convert one-time sales (I3.0) into *continuous* revenue streams (e.g. subscription) and customer *lock-in* (I4.0). Predictive maintenance with more efficient service scheduling supports providers to *reduce own costs*.

Servitization includes offering complementary services to traditional product sales (*life-long partnerships*) and substituting product sales with services that include a product (*product as a service* and *result as a service*). The latter two sub-archetypes eliminate high investment costs for customers and, thus, address *new customer segments*. The sub-archetypes are an implementation of product service systems types according to Tukker (2004), Reim et al. (2015) and Weking et al. (2018) in the I4.0 context.

Life-long partnerships. IoT connected products enable this archetype to evolve its service portfolio from repair after failure and maintenance (I3.0) to prevent failures with *remote monitoring and predictive maintenance* throughout the whole product life cycle (I4.0). The firm becomes a *solution provider* with integrated product service solutions and a partner for customers for the entire product use phase. Before (I3.0) as well as after the BMI (I4.0), a firm generates significant parts of turnover by *selling* tangible products and transferring their *ownership rights* to customers. In I4.0, firms add continuous revenue streams with *subscription-based*, lifelong service contracts (I4.0). AVL List, for example, is a leading provider for tailored powertrain development and test system solutions. The firm offers *remote usage and condition monitoring* in addition to product sales. AVL aims to optimize product lifetime. They proactively exchange weak parts to avoid breakdowns.

Product as a service. *Renting* products (I4.0) instead of selling products and related services (I3.0) shapes this sub-archetype. Customers do not pay for ownership or service delivery (I3.0) but for *use and availability* of the product (I4.0). It provides new customer value by *guaranteeing* the products *availability*. Konecranes, for example, does not only sell industrial cranes (I3.0), but also rents them out based on a monthly fee (I4.0).

Result as a service. Selling the *output or result* of the product characterizes *result as a service*. This also enables *continuous* revenues streams. The sub-archetype allows for *full-service packages* and takes responsibility for safe operations and compliance. Kaeser, for example, innovates from selling compressors (I3.0) to selling compressed air per cubic-meter (I4.0). Kaeser takes full responsibility and operates compressors at the customer's site.

Expertise as a service – Hybrid BMI

The super-archetype uses internally-build expertise of products or processes and offers it as a new consulting service (sub-archetypes product related and process related consulting) or a new product (sub-archetypes broker platform and IoT platform) to external customers (*make more of it*). The consulting sub-archetypes shift the value chain focus on *service and support*. They require the human role of *consultants* as key resources. Both transform the meta-dimensions value proposition and architecture. Value capture and value chain remain unchanged, i.e. one-time sales of new services in addition to traditional products manufacturing and sales (I3.0). The platform BMs offer a new platform-based, *digital product* together with complementary *IT services*. This shifts the firm's role in the value chain to an *intermediary* and creates a *multi-sided market*. The BM addresses at least two independent customer groups. The meta-dimension value capture moves from one-time sales to *continuous* subscription fees from different user groups, e.g. commissions from third parties (*revenue sharing*).

Product related consulting. The product related consulting complements product sales (I3.0) with advice and consulting (Tukker 2004) based on own experiences with the products. Firms provide new value to *existing customer segments* by offering integrated product service solutions (*solution provider*). This transition changes the meta-dimension architecture (product/ service line extension and evolution of existing BM). Kaeser, for example, makes use of its know-how about its compressors by offering tailored system planning and energy saving consulting. They help customers to make optimal use of the product. In contrast, servitization archetypes cover repair, maintenance or operating services and not consulting.

Process related consulting. The process related consulting builds on experiences of internal processes. Firms offer this know-how as an advice and consultancy (Tukker 2004) to externals. This new service does not involve a tangible product. It addresses existing as well as new customer segments by approaching with a new value proposition, e.g. consulting about smart production and digital transformation. Compared to product related consulting, the meta-dimension architecture changes more radical. Here, the BMI is *new for the company* and may result in a company *spin-off*. TRUMPF, for example, a pioneer within I4.0, offers its internally gained know-how about its transformation from I3.0 to I4.0 as consulting service with its spin-off AXOOM.

Broker platforms. The archetype broker platforms describes how firms use experience from existing manufacturing and selling asset-intensive machinery (I3.0) and turn it into new *digital products* (I4.0). In our case studies, the new product is a cloud based platform for trading goods and services among user groups. Claas, for example, extends its manufacturing and selling farm machinery (I3.0) by offering a cloud-based software solution for farm management with its spin-off 365Farmnet. Thus, they use the IoT data from tractors and address further pain points of their customers, such as farm management, crop planning and paper work. TRUMPF, as a second example, manufactures and sells machine tools (I3.0) and additionally operates a trading platform for process parameters of their machine tools (I4.0). They help customers to adapt process parameters to new materials or production routings more efficiently.

IoT platforms. This sub-archetype makes use of experience on internal processes and smart production and transforms it into a new product. In our cases, the new product is an IoT platform. This is the basis for communities that can develop and sell complementary products. In contrast to the BM broker platform, *analytics* are key activities for this BM. The GE Software Center, for example, developed the IoT platform Predix as an internal solution for machine operators and maintenance engineers. They aimed to reduce GE machine downtimes and to schedule maintenance checks more economically (Schaefer et al. 2017; Winnig 2016). However, they started to offer customers an industrial IoT platform. They used their knowledge of their own analytics platform to extend their product portfolio due to market demand.

Discussion and Conclusion

In this study, we address the lack of research about I4.0 and related BMs and BMIs. Current research only analyzes I4.0 regarding technological and regulatory aspects. Based on 15 case studies, we create a taxonomy of I4.0 BMs for characterizing and structuring BMs and derive 13 archetypes of I4.0 BMIs capturing their transition from I3.0 BMs to I4.0 BMs.

Our study has two main implications for research. First, the taxonomy of I4.0 BMs and archetypes of I4.0 BMIs show how manufacturing firms use digital technologies to expand their competitive advantage. *Integration* cases mainly build on new online channels, i.e. online shops and innovation platforms, and digital manufacturing. Covering more parts of the value chain replaces intermediaries and enables faster reaction to changing customer demands. Firms integrate customers and other externals in product design and development. Customization options in online shops enable individualized products at competitive prices to mass products. New digital manufacturing techniques, such as 3D printing, reduce the labor intensity and allow production close to the market. The direct digital-to-physical transfer allows adaption to changing market requirements and a shorter time to market. *Servitization* cases especially use CPSs, IoT and analytics. IT-enabled remote product monitoring and predictive maintenance services reduce downtime of the customer's plant and help customers to reduce costs. Customer contact extends to the whole product lifecycle. Providers generate continuous revenue streams due to multi-year contracts and increase the customers' switching costs. Additionally, remote monitoring and predictive maintenance help providers to reduce their own service costs with more efficient scheduling of service teams and maintenance visits. Real-time monitoring makes rental more attractive and enables usage-based revenue models. *Expertise as a service* cases strategically use IT to offer new, complementary goods and services. In our cases, new products are or emerge from IoT platforms, digital trading platforms, or two-sided market platforms for business applications. These products also enable new, digital processes. Further, providers use their expertise of digital products and processes to consult customers. Overall, the results show how the combination of new technologies and BMs lead to competitive advantage, which remains a challenge in research (Chesbrough 2010). Second, the taxonomy of I4.0 BMs reveals how digital technologies support specific BM components (Saebi et al. 2016). Digital technologies enable continuous, usage-based revenue models as part of the value capture component. Manufacturing firms use platforms and new forms of analytics as new key elements. Firms can address new customer segments online and directly. Digital products and services change the value proposition component. Digital technologies may transform the value chain towards decentralized, individualized and on-demand production. They support the vertical and horizontal end-to-end integration of the value chain. Hence, the taxonomy and archetypes reveal that all BM components may change in I4.0, in contrast to its initial understanding that mostly the value proposition, core competencies and relationships change (Arnold et al. 2016).

For practice, this paper shows how to use or build upon I4.0 including smart manufacturing, CPS and IoT. Practitioners can use our taxonomy to assess the I4.0 readiness of their current BM. Locating their BM within the taxonomy indicates which dimensions must be adapted to transform an I3.0 BM into an I4.0 BM. The characteristics of the taxonomy and the case examples may inspire practitioners about how to innovate their BM, and allow managers to discover BMI opportunities. The 13 archetypes provide guidance for the transformation process by specifying the relevant meta-dimensions that the BMI affects most. Firms can use archetypes and related cases in an ideation phase to identify options for BMI and assess their implementation in the firm's context.

The main limitation of our work is the lack of available case studies. We could only find 15 case studies about I4.0 BM innovators with sufficient information for further analysis. Additionally, we do not have access to quantitative data showing how successful the analyzed cases are.

Future research can build on the taxonomy and archetypes. The taxonomy structures characteristics of I4.0 BMs and the archetypes show general, distinct types of I4.0 BMIs. This helps future research to explain and analyze I4.0 BMs and BMIs more precisely. Additional case studies can further investigate the use of specific digital manufacturing and integration techniques, products and services and their influence on competitive advantage. Future studies can use the taxonomy and the 13 archetypes to analyze the co-occurrence of archetypes and dominant, digital transition paths from I3.0 to I4.0 BMs.

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Appendix D. Leveraging Industry 4.0 – A Business Model Pattern Framework (P4)

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Leveraging industry 4.0 – A business model pattern framework

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ABSTRACT

Industry 4.0 (I4.0), also known as the fourth industrial revolution, describes the digitalization of manufacturing industries. The transition to I4.0 is crucial for manufacturing firms to sustain competitive advantage and seize new opportunities. Most research has focused on the technological aspects of I4.0 in the form of product and process innovations. Despite I4.0's rising attention from both researchers and practitioners, little research exists about I4.0 business model (BM) innovation, even though BM innovations can be more successful than product or process innovations. To address this research gap, we analyze 32 case studies of I4.0 BM innovators. We develop a taxonomy to characterize I4.0 BMs and derive 13 patterns of I4.0 BMs by applying the taxonomy to the case studies. Three super-patterns are identified: *integration*, *servitization*, and *expertization*. *Integration* innovates a BM with new processes and integrates parts of the supply chain. New combined products and services are the basis for *servitization*. *Expertization* is a hybrid of product- and process-focused BMs, which includes consulting services and multi-sided platforms. This study contributes to research with a framework for describing, analyzing, and classifying BMs for I4.0. The findings deepen the understanding of how I4.0 impacts ecosystem roles, BMs, and service systems. Archetypal patterns show how firms can leverage I4.0 concepts and build a conceptual basis for future research. The taxonomy supports practitioners in evaluating the I4.0-readiness of their existing BM. The patterns additionally illustrate opportunities for becoming an I4.0 firm.

1. Introduction

Gearing traditional industries toward the opportunities and challenges of digitalization is frequently discussed among researchers and practitioners around the globe. *Advanced Manufacturing Partnership* in the United States, *La Nouvelle France Industrielle* in France, *Future of Manufacturing* in the United Kingdom, and *Made in China (2025)* alongside the *Internet Plus* in China are just some examples of government initiatives that address the convergence of traditional industrial production with IT and new technologies, such as the Internet of Things (IoT) (Hermann et al., 2016; Liao et al., 2017; Ramsauer, 2013). The name of the equivalent German campaign *Industry 4.0* (I4.0), has evolved as an eponym for a new manufacturing landscape based on advanced digitalization and automation (Liao et al., 2017; Pereira and Romero, 2017). All of these programs aim at bringing new technologies to traditional manufacturers, as many of these firms are digital laggards (Gallagher, 2017). Further, the manufacturing sectors are the backbones of several industrial nations. In Germany, for example, manufacturing contributes to more than 25% of GDP and employs more than one-sixth of the total workforce (Statista, 2018a, 2018b). Thus, initiatives aimed at securing competitiveness and economic wealth for the industrial nations in the long run are very important (Ramsauer, 2013).

Researchers, as well as consulting firms, have already recognized the digital innocence of manufacturers and the economic potential behind I4.0. *Industry 4.0: The Future of Productivity and Growth in Manufacturing Industries* (BCG, 2015) or *Manufacturing's Next Act* (McKinsey, 2015) are just a few catchy headlines of practitioner reports about I4.0. These reports promise firms economic prosperity from applying new technologies. Roland Berger (2016), for example, estimates a potential of €450 billion of net profits and capital employed in Europe due to the upgrade from Industry 3.0 (I3.0) to I4.0. Likewise, there are claims in the literature that manufacturing firms have to innovate their business model towards servitization, cloud manufacturing, intelligent manufacturing, C2B manufacturing, and so on (Rabetino et al., 2017; Wei et al., 2017).

Despite the increasing interest in and importance of the economic aspects of I4.0, research has mainly focused on its technological

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implications (Burmeister et al., 2016; Kiel et al., 2016). Several general studies, however, show that businesses struggle with profiting from new technologies without applying adequate business models (BM) (Abdelkafi et al., 2013). Further, not only product and process innovations but also business model innovations (BMI) are essential for future success (Wischmann et al., 2015). BM innovators are even more successful than pure product or process innovators (Böhm et al., 2017; Gassmann et al., 2014; Weking et al., 2019). "A mediocre technology pursued within a great business model may be more valuable that a great technology exploited via a mediocre business model" (Chesbrough, 2010). The inability to adapt BMs to new economic conditions can ultimately kill a firm (Gassmann et al., 2014; Wirtz et al., 2010).

BMI does play a minor role in I4.0 specific literature and generally the question of how new technologies affect traditional BMs is understudied (Bock and Wiener, 2017; Rayna and Striukova, 2016). The term I4.0, however, is associated with several advancements that assume the opportunity or even the requirement to change current BMs (Kagermann et al., 2013). Consequently, manufacturers do not know what new BMs under I4.0 can look like (Sarvari et al., 2018) and how to transform traditional BMs for I4.0 (Grünert and Sejdić, 2017). Firms struggle with BMI because they do not "understand their existing BM well enough to know when it needs changing – or how" (Johnson et al., 2008). So, I4.0 BMI approaches are mostly based on trial and error, and lack systematic guidance (Laudien and Daxböck, 2016).

Business model patterns (BMP) are a practice-proven approach for innovating BMs systematically and efficiently (Amshoff et al., 2015). BMPs represent recurring building blocks of a BM that document the BM logic abstractly and generally (Amshoff et al., 2015; Rudtsch et al., 2014) and can emerge as a result of a BMI process (Massa and Tucci, 2014). Gassmann et al. (2014) show that 90% of all BMIs are simply a recombination of existing patterns. They provide a common vocabulary for systematically describing BMI options (Bocken et al., 2014). Scholars call for the transfer of BMPs to industries under change (Remané et al., 2017b). Except for a few studies about BMPs in I4.0-related areas, for example, IoT BMPs (Fleisch et al., 2014), no study has systematically analyzed BMPs for I4.0. Further, as BMs are often a combination of several atomic BMPs, insights about their co-occurrence and interactions are crucial to completely penetrating the BM logic (Amshoff et al., 2015).

For this, taxonomies are a popular means of explanation (Bock and Wiener, 2017). A taxonomy refers to a "form of classification" which is a "conceptually or empirically derived grouping" that helps researchers and practitioners to analyze, structure, and understand complex domains (Nickerson et al., 2013). Moreover, taxonomies support deriving patterns, as they clarify the standard and unique building blocks of BMs (Bock and Wiener, 2017). Recent studies have developed taxonomies and patterns for domain-specific BMs in I4.0-related areas, for example, for digital BMs (Bock and Wiener, 2017; Remané et al., 2017a), platform BMs (Täuscher and Laudien, 2018), or data-driven BMs (Hartmann et al., 2016). These taxonomies, however, are either too general or too specific to classify I4.0 BMs. In conclusion, the extant literature provides only a small amount of conceptual guidance regarding the research question:

RQ: What are business model patterns for Industry 4.0?

To address this question, this paper investigates BMs in the context of I4.0. We collect and analyze 32 case studies about I4.0 BMI from scholastic and practitioner reports. We develop a taxonomy to describe the I4.0 BMs using existing BMPs. Based on the taxonomy, we derive 13 BMPs particularly for I4.0.

Our work contributes to the literature on production economics and business models with a framework for describing, analyzing, and classifying BMs for I4.0. It furthers the understanding of how I4.0 impacts ecosystem roles, BMs, and service systems. The taxonomy and archetypal patterns show how firms can leverage I4.0 technologies and concepts and build a basis for future research on I4.0. Practitioners can benefit from our work as the taxonomy can help them to evaluate the I4.0-readiness of their existing BMs. The patterns and related cases promote creativity and illustrate opportunities for becoming an I4.0 firm. This paper is a revised and extended work of our first idea published as conference paper (Weking et al., 2018).

2. Related work

2.1. *Defining industry 4.0*

To analyze I4.0 BMs, we first clarify I4.0. There is no consensual definition of the term I4.0 or dissociation of its predecessor, I3.0 (Hermann et al., 2016; Pereira and Romero, 2017). Some authors define I4.0 as (1) the process "toward the increasing digitization and automation of the manufacturing industry" (Brettel et al., 2014; Oesterreich and Teuteberg, 2016), and some as (2) a new stage or paradigm for industrial production (Kagermann et al., 2013; Pereira and Romero, 2017), focusing on the outcome of a transformation process. Other authors mix both perspectives (i.e. transformation process and its outcome) or use I4.0 as (3) an umbrella term for new technologies and concepts (Hermann et al., 2016; Pfohl et al., 2015). Thus, the term I4.0 covers both, the digital transformation of (process perspective), and a new manufacturing paradigm for (outcome perspective), traditional industries. To analyze I4.0 BMs as the outcome of BMIs, we follow the outcome perspective and see I4.0 as the fourth stage of industrial production.

In the first stage, water and steam power enabled mechanical production at the end of the 18th century (Industry 1.0). The intensive use of electrical power and the division of labor in assembly lines allowed mass production at the end of the 19th century and the beginning of 20th (Industry 2.0). The use of IT and electronics and the introduction of programmable logic controllers enabled automated production in the second half of the 20th century (I3.0). Cyber-physical systems (CPS), IoT, and smart factories permit smart production nowadays (I4.0) (Hermann et al., 2016; Kagermann et al., 2013; Lasi et al., 2014; Pereira and Romero, 2017). "Smartness" covers the ability to communicate and cooperate in real time, to make decisions autonomously, and to steer oneself based on information obtained (Pereira and Romero, 2017). Thus, the speed of change is getting faster.

The term Industrial Internet of Things (IIoT) is often used to denote the international description of I4.0 (Arnold et al., 2016; Huxtable and Schaefer, 2016; Kiel et al., 2017). It describes the application of the IoT in the industrial context, that is the connection of devices in a factory (Gierej, 2017). Additionally, it stands for the vision of a new manufacturing landscape with real-time communication of smart machines, smart objects, and people (Arnold et al., 2016; Huxtable and Schaefer, 2016). Technically speaking, the IoT is a fundamental *part* of the fourth stage of industrial production, but I4.0 also involves other elements (Gierej, 2017).

CPS, IoT, and smart factories are fundamental technical enablers of I4.0. CPSs are technological systems consisting of physical parts, embedded sensors and actuators, and digital parameters, whose physical and virtual components are merged so that they "cannot be differentiated in a reasonable way anymore" (Lasi et al., 2014). CPS's internet connection form the foundation of the IoT (Pereira and Romero, 2017). The IoT connects physical objects, people, systems, and IT, allowing things to communicate and control each other (Oesterreich and Teuteberg, 2016; Pereira and Romero, 2017). Devices connected to the IoT and equipped with memory are called smart objects, and these can interact with each other in real time. They can make decisions and perform actions independently and autonomously based on obtained information (Pereira and Romero, 2017). CPS and IoT when integrated in manufacturing enable smart processes, products, machines, systems and factories (Hermann et al., 2016). A smart factory contains the manufacturing resources of an entire production site that can independently communicate and exchange information with itself, trigger and control the next actions, and steer production (Brettel et al., 2014; Lasi et al., 2014; Pereira and Romero, 2017; Ramsauer, 2013). "Context-aware, the factory can assist people and machines in execution of their tasks" (Hermann et al., 2016), by drawing on information from the physical and virtual world.

2.2. Business models

To identify BMPs for I4.0 as results of BMI, we first differentiate the general concepts of BM, BMI and BMP without relating them to I4.0. Despite enormous research about BMs, no commonly accepted interpretation or definition has yet been established (Foss and Saebi, 2017; Massa et al., 2017; Schneider and Spieth, 2013). Massa et al. (2017) distinguish between three interpretations of BMs, that is as "attributes of real firms," as "cognitive/linguistic schemas," and as "formal conceptual representations." We use BMs as formal conceptual representations to abstract from single cases to generalizable BMPs. In this interpretation of BMs, its definition converges on four components and their relations using different terminology: value proposition, market segments, structure of the value chain, value capture mechanisms and "how these elements are linked together in an architecture" (Foss and Saebi, 2017; Saebi et al., 2017). Other common approaches, such as Teece (2010), and practitioner-oriented approaches, such as the Business Model Canvas (Osterwalder and Pigneur, 2010) or the Business Model Navigator (Gassmann et al., 2014), confirm these four elements, on which this paper builds (see Table 1).

The research stream of BMI covers changes in a firm's BM, such as innovating from a traditional BM to an I4.0 BM. BMI recognizes the BM as a potential source of innovation that is distinct from product, service, process and organizational innovation (Foss and Saebi, 2017; Zott et al., 2011). "BMIs are designed, novel, nontrivial changes to the key elements of a firm's business model and/or the architecture linking these elements" (Foss and Saebi, 2017). This commonly used definition allows us to capture BMIs that result in I4.0 BMs. "Designed" implies that BMI is a deliberate change to a current BM, for example, towards I4.0. "Novel, non-trivial changes" excludes minor adaptions of the existing BM, such as adding a new supplier. BMI changes the BM more radically, such as innovating towards I4.0 (Foss and Saebi, 2017).

To systematically and efficiently support BMI, applying BMPs is a practice-proven approach (Amshoff et al., 2015). Thus, we build on BMPs to describe and analyze I4.0 BMs resulting from BMI toward I4.0. Patterns describe both a recurring problem and the core of its solution in such an abstract way that they can be reused for several issues multiple times (Alexander, 1977). Transferring this to BMs, a BMP captures the core of a recurring BM design problem and the corresponding BM design solution in such an abstract way that it can be applied in BMs of various firms from different industries and markets. Firms can reuse BMPs at different times by applying the abstract pattern to the firm's specific requirements (Abdelkafi et al., 2013; Amshoff et al., 2015; Osterwalder and Pigneur, 2010; Remané et al., 2017; Weking et al., 2018). BMPs represent a systematic and efficient approach for all phases of the BMI process (Amshoff et al., 2015; Gassmann et al., 2014; Remané et al., 2017b). For example, BMPs help firms to understand and describe their own BM and the dominant industry logic. Additionally, they serve as inspiration for new BMs by transferring patterns from other firms and industries to a firm's own BM (Gassmann and Csik, 2012; Remané et al., 2017b). By aggregating previous work, Remané et al. (2017b) present a database of 182 distinct, generally applicable BMPs. This collection is the foundation for our work of identifying I4.0-specifc BMPs.

Table 1
Components of business models.

Foss and Saebi (2017), Saebi et al. (2017)	Teece (2010)	Osterwalder and Pigneur (2010)	Gassmann et al. (2014)
Market segments	Customers	Customer segments	Who is the target customer?
Value proposition	Value	Value proposition	What does the customer value?
Structure of the value chain	Value creation, Value delivery	Key partners, Key activities, Key resources, Customer relationships, Channels	How is the value proposition built and distributed?
Value capture mechanisms	Value capture mechanisms	Revenue streams, Cost structure	Why is the BM financially viable?

2.3. Business models in industry 4.0-related areas

Although research on BMs for I4.0 is immature, research on BMs for some I4.0-related topics has been well explored. This subsection summarizes work on BMs in I4.0-related areas: open innovation (OI) and crowdsourcing, mass customization, product service systems (PSS), and IoT. These types of BMs are strongly linked to I4.0 BMs because all of them are enabled and/or supported by the fundamental technical enablers of I4.0 BMs: CPS, IoT, and smart factories.

2.3.1. Open innovation and crowdsourcing business models

CPS, IoT, and smart factories, as fundamental technical enablers of I4.0 BMs, intensify internal and external communication, which enables open innovation and crowdsourcing BMs. Global competition, rising research and development (R&D) and technology costs, and shorter product life cycles require firms to open their innovation processes, shifting from closed innovation toward OI (Chesbrough, 2007; Saebi and Foss, 2015). OI covers two directions: outside-in and inside-out. Outside-in OI describes innovation activities that include external expertise, for example, from suppliers, customers, or other organizations. Inside-out OI means selling underutilized or unused ideas to other parties (Chesbrough, 2012). An OI strategy changes traditional BMs to open BMs (Chesbrough, 2007; Saebi and Foss, 2015). "An Open Business Model is a BM characterized by the active search and exploitation of external ideas and/or licensing internal technologies and ideas to other firms" (Chesbrough, 2007). Thus, OI covers various innovation activities, such as buying or licensing technology, hosting innovation contests, engaging in crowdsourcing, or forming R&D alliances or joint ventures (Saebi and Foss, 2015; Füller et al., 2019).

Crowdsourcing is a subtype of OI (Kohler, 2015; Saebi and Foss, 2015) and describes outsourcing a task once performed by employees to an undefined, vast network of ordinary people. Jobs can be completed collaboratively or by individuals (Djelassi and Decoopman, 2013). Crowdsourcing affects several aspects of traditional BMs. The customer role changes from a passive consumer and purchaser to a value co-creator and key partner (Djelassi and Decoopman, 2013; Kohler, 2015). Crowdsourcing can open new customer segments, as individuals can take part who are not yet a customer (Djelassi and Decoopman, 2013).

2.3.2. Mass customization business models

Regarding mass customization, fundamental technical enablers of I4.0 BMs, such as CPS, IoT, and smart factories, enable small lot sizes and, thus, mass customization. Mass customization describes the production of individually adapted goods for a large sales market at costs comparable to standard goods (Bullinger and Schweizer, 2006). It provides the benefits of both mass production and handicraft (Bullinger and Schweizer, 2006). Advancements in IT enable this production paradigm. For example, computer-aided design software allows customers to adapt product features before buying and gives visual feedback about the modified product in real time (Grimal and Guerlain, 2014). IT enables the immediate translation of product orders into a list of materials and transfers the required tasks to the production system (Grimal and Guerlain, 2014). Mass customization typically requires IT in the form of e-commerce and online shops for the necessary interaction with customers and suppliers (Bullinger and Schweizer, 2006; Grimal and

Guerlain, 2014).

The shift from mass production to mass customization affects BMs. Coordination between demand and supply tighten and information-sharing between organizations become standard (Bullinger and Schweizer, 2006). Linear supply chains transform to digitally connected value networks (Bullinger and Schweizer, 2006). Firms need to more closely involve customers into their production process (Grimal and Guerlain, 2014). IT will continue to decrease transaction costs and time-to-market (Grimal and Guerlain, 2014).

2.3.3. Product service systems business models

PSS is another BM type that is enabled by fundamental technical bases of I4.0 BMs (Weking et al., 2018). The service component of PSS heavily builds on data from CPS, IoT, and smart factories (Basirati et al., 2019). PSSs describe a combination of tangible products and intangible services that jointly fulfill certain customer needs (Reim et al., 2015; Tukker, 2004), whereas servitization means integrating or increasing the share of service components in a firm's portfolio (Foss and Saebi, 2017; Witell and Löfgren, 2013). PSSs describe a particular type of servitization in the manufacturing industry (Gerrikagoitia et al., 2016). PSS-based BMIs are popular among manufacturing firms that are aiming at closer customer contact, more stable revenue streams, and improved resource utilization (Reim et al., 2015; Velamuri et al., 2013; Witell and Löfgren, 2013). Shifting from product sellers to customer problem-solvers or solution providers (Remané et al., 2017b), firms provide new customer value by mitigating risks and improving operating performance or asset effectiveness (Velamuri et al., 2013). Tukker (2004) identifies eight archetypical PSS BMs and groups them into three main categories: product-oriented, use-oriented, and result-oriented PSS. Table 2 provides an overview.

2.3.4. Internet of Things business models

IoT itself is a fundamental technical enabler of I4.0 BMs. Related BMs, IoT BMs, show the value proposition as the most important element (Dijkman et al., 2015; Ju et al., 2016; Metallo et al., 2018; Rong et al., 2015), particularly in the industrial context (Arnold et al., 2016; Kiel et al., 2017). A new value proposition can be a holistic solution that solves a customer's problem (Dijkman et al., 2015; Kans and Ingwald, 2016), or an increased convenience (Dijkman et al., 2015). Additionally, the IoT affects customer relationships, key resources and key partners (Arnold et al., 2016; Dijkman et al., 2015; Kiel et al., 2017). IoT BMs integrate customers in the product engineering and design process (Arnold et al., 2016; Dijkman et al., 2015; Gierej, 2017; Kiel et al., 2017). Software and human resources with IT qualifications (e.g., data analytics or software development) become key resources of IoT BMs (Arnold et al., 2016; Gierej, 2017; Ju et al., 2016; Kiel et al., 2017). The employee's role changes from operator to problem solver (Arnold et al., 2016). Typically partnerships with suppliers of IoT devices and IT partners become crucial for IoT BMs (Arnold et al., 2016; Dijkman et al., 2015; Gierej, 2017; Kiel et al., 2017). Fleisch et al. (2014) introduce eight BMPs for the IoT, which we include in our analysis, for example, remote usage and condition monitoring and digitally charged products. However, none of the concepts above cover all of the specific characteristics of I4.0 BMs. Thus, this paper investigates BMPs particularly for I4.0.

3. Research approach

To analyze I4.0 BM as a "contemporary phenomenon in its real-world context", a case-based approach with many I4.0 cases is most fitting (Yin, 2014). Qualitative, multiple case studies allows to gain in-depth understanding (Yin, 2014) as well as generalizable, cross-sectional analyses, such as in case surveys (Larsson, 1993). Our approach has two phases. First, we set up a case base comprising 32 I4.0 BMI cases. The unit of analysis of these cases is the BM at the level of a strategic business unit (Cao et al., 2018). Thus, we can focus solely on I4.0 BMs. For example, we analyzed Daimler Mobility Services as a case without considering Daimler's traditional BM of vehicle manufacturing. For smaller firms with one strategic business unit, the level of analysis correlates with the whole organization's BM, for example, Local Motors, Ponoko, or Shapeways. Second, we develop a taxonomy in three iterations, derive I4.0 BMPs based on the case studies and the taxonomy, and empirically and theoretically evaluate both results. A taxonomy and related BMPs allow us to collect and provide a structured overview of characteristics of various I4.0 BMs. Thus, we can visually show which BM attributes are archetypal for I4.0 BMs.

3.1. Case base (Empirical foundation)

We used the databases EBSCOhost, ScienceDirect, Scopus, Springer Link, IEEE Explore, and the Web of Science, Google Search, and practice reports (e.g., McKinsey, BCG, Accenture, Microsoft) to find case studies about I4.0. We also considered IIoT and data-driven cases that fit the I4.0 definition. Our inclusion criteria were:

- The BMI of the case forms a final BM that matches our understanding of an I4.0 BM.
- The case provides sufficient information to characterize its BM including value proposition, market segments, structure of the value chain, value capture mechanisms, and "how these elements are linked together in an architecture" (Foss and Saebi, 2017; Saebi et al., 2017).
- The case description includes the firm name, so that we can search for additional information and, thus, support data triangulation (Yin, 2014).

We obtained an initial set of 39 use cases with several references each. To augment the case data and to support data triangulation (Yin, 2014), we manually searched for additional information on the firms' websites, in newspaper articles, publicly available interviews, and press releases and gathered it in a case base (Yin, 2014). Finally, we checked all cases again for sufficient information about the case's BM. This resulted in 32 cases with two degrees of detail: category A and category B. The 15 instances of category A provide rich information on various dimensions of their BMs, which is necessary for *developing* a BM taxonomy and archetypal BMPs. The 17 cases of category B provide less information, but enough detail to *evaluate* both the taxonomy and the patterns (see Table 3 and Table A1 for analyzed sources).

3.2. Taxonomy and patterns

We applied the method suggested by Nickerson et al. (2013) to systematically develop a taxonomy for I4.0 BMs. This method allows to combine theoretical findings about BMs with the empirical results of case studies (Remané et al., 2016). We conducted three iterations (see Fig. 1) (Nickerson et al., 2013).

Source: Own illustration based on Nickerson et al. (2013).

First, we specified meta-characteristics that "serve as the basis for

Table 2
Product service systems business models.

Category	product-oriented		use-oriented			result-oriented		
Business Model	Product-related	Advice and consulting	Product lease	Product renting or sharing	Product pooling	Activity mgt./ outsourcing	Pay per service unit	Functional result

Table 3
Case studies of Industry 4.0 business model innovators.

No.	Category	Firm	Main empirical study	Analyzed sources
1	A (rich data)	Adidas	Plattform-i40 (2017)	11
2		Atomic	Lassnig et al. (2017)	5
3		AVL	Lassnig et al. (2017)	4
4		Caterpillar	Schaefer et al. (2017)	5
5		Claas – 365Farmnet	Bauernhansl et al. (2015)	7
6		eMachineShop	Bauernhansl et al. (2015)	4
7		GE Digital	Schaefer et al. (2017)	7
8		KAESER Compressors	Kaufmann (2015)	6
9		Konecranes	Wortmann et al. (2017)	5
10		Local Motors	Bauernhansl et al. (2015)	7
11		Ponoko	Gassmann et al. (2014)	4
12		Shapeways	Bauernhansl et al. (2015)	5
13		Texa CARe	Microsoft (2017a)	4
14		TRUMPF – AXOOM	Grünert and Sejdić (2017)	7
15		Zumtobel	Lassnig et al. (2017)	4
16	B (lesser data)	ABB Marine Systems	Wortmann et al. (2017)	2
17		ABT Power Management	Microsoft (2018)	2
18		Biesse Group	Accenture (2018)	2
19		Bosch Engineering	Wortmann et al. (2017, p. 12)	3
20		Daimler Mobility Services	Bauernhansl et al. (2015)	8
21		GE Fuse	BCG (2017)	6
22		GE Taleris	Daugherty et al. (2015)	4
23		Hilti	Wortmann et al. (2017)	7
24		Michelin	Daugherty et al. (2015)	4
25		New Balance	BCG (2017)	4
26		Pirelli	Schaefer et al. (2017)	6
27		Rolls-Royce	Microsoft (2016)	4
28		Samudra LED	Microsoft (2017b)	3
29		Schlotterer	Lassnig et al. (2017)	5
30		Siemens	Plattform-i40 (2018)	1
31		ThyssenKrupp Elevator	Microsoft (2014)	2
32		Würth Industrie Service	Bauernhansl et al. (2015)	5

[the] choice of characteristics in the taxonomy" and the ending conditions for terminating the iterative approach (Nickerson et al., 2013). We chose four generally accepted BM components as meta-characteristics: target customer, value proposition, value chain, and value capture (Gassmann et al., 2014). Each dimension and characteristic of the taxonomy must relate to these characteristics, which help to identify and organize relevant dimensions (Remané et al., 2016). We used the eight objective and five subjective ending conditions suggested by Nickerson et al. (2013), following Bock and Wiener (2017).

3.2.1. 1st iteration: conceptual development

Second, we developed the taxonomy with three iterations. The first iteration was conceptual-to-empirical and derived dimensions and characteristics of I4.0 BMs from literature. We used findings about BMs and I4.0, which the related work section outlines. We derived 11 dimensions with two to nine characteristics each based on 55 papers (see Table 4).

3.2.2. 2nd iteration: empirical development

The second iteration was empirical-to-conceptual by applying the taxonomy from the first iteration to the 15 case studies of category A. We randomly chose an instance and conducted a qualitative structured data analysis (Miles et al., 2013). We coded the case information with BMPs from the literature (Remané et al., 2017b) and empirically derived characteristics (within-case analysis) (Yin, 2014). Then, we classified the case within the taxonomy and, if necessary, added further characteristics and dimensions to the taxonomy until all cases were included. Here, we split the component of value creation into two meta-dimensions – value chain and key elements – to improve the structure. We dropped and synthesized characteristics and dimensions to keep the taxonomy lean without losing discriminative power.

To derive I4.0 BMPs, we applied our taxonomy to the 15 cases in the form of a within-case analysis (Yin, 2014). We found that some cases do

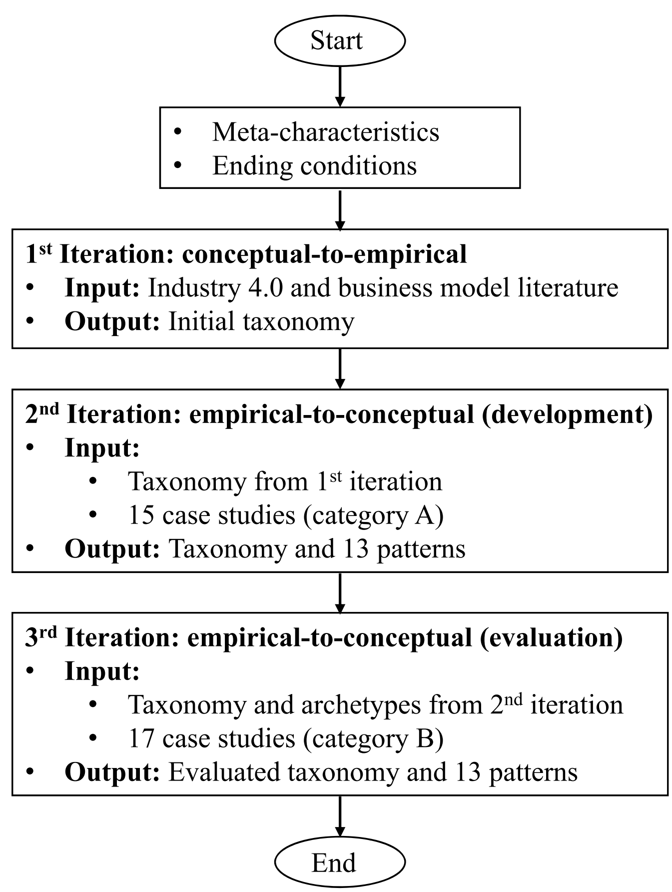

Fig. 1. Taxonomy development approach.

Table 4
First iteration of industry 4.0 business model Taxonomy.

Meta-Dim.	Dimensions	Characteristics								
Target Customers (Who)	Market	B2B (37)	B2C (25)	B2B and B2C (22)	B2G (5)					
Value Proposition (What)	Product	Product (21)	Service (27)	PSS (37)						
	Digital Degree	Physical (23)	Digital (22)	Hybrid (41)						
	As a Service	Platform aaS (12)	Software aaS (9)	Infrastructure aaS (6)	Data-aggregation aaS (13)	Analytics aaS (11)				
	Value Proposition	Solution Provider (27)	Scalability (14)	Cost efficiency (30)	Financial risk reduction (10)	Time savings (13)	Sustain-ability (17)	Transparency (15)	Custo-mization (26)	Matching (10)
Value Chain (How)	Innovation	Open innovation (32)	Open source (7)							
	Production	Modularization (10)	Mass customization (9)	From-push-to-pull (14)						
	Sales Channel	Direct selling (16)	E-commerce (24)							
Value Capture (Why)	Revenue Model	Sales (19)	Revenue sharing (16)	Licensing (13)	Rent/ lease (16)	Usage fee (15)	Subscription (14)			
	Payer	User (10)	Customer (29)	Third party (11)						
	Pricing	Pay-per-use (24)	Fixed price (23)	Free (7)	Flatrate (8)	Freemium (10)				

The number in brackets indicates the number of papers supporting this characteristic.

not follow one specific BM but apply a mix of different BMs. Thus, more than one characteristic per dimension could apply for each BM innovator, which differs from Nickerson et al. (2013). Second, we generalized from the cases classified by the taxonomy and conducted a qualitative cluster analysis as a cross-case analysis (Yin, 2014) using constant comparison (Eisenhardt, 1989; Eisenhardt and Graebner, 2007), following Cao et al. (2018). We initially identified 10 patterns with each covering cases with similar BM characteristics. To ensure clarity and applicability, we again conducted a qualitative cluster analysis as a cross-case analysis (Yin, 2014) with the 10 patterns to inductively generate overarching patterns. This resulted in three super-patterns, which cover common characteristics of their underlying sub-patterns. Altogether, we identified 13 patterns: Three super-patterns and 10 underlying sub-patterns.

3.2.3. 3rd iteration: empirical and theoretical evaluation

The third iteration also followed the empirical-to-conceptual approach. We used the taxonomy to code the 17 lower-information cases of category B (Miles et al., 2013). The taxonomy enabled us to search pointedly for missing information. Additionally, we applied the 13 patterns to classify the 17 lower-information cases. Again, we used multiple sources and triangulated the data to corroborate results (Yin, 2014). The taxonomy and patterns did not need any changes in this iteration, which terminates the development process and starts the evaluation (Nickerson et al., 2013).

To empirically evaluate the taxonomy and identified patterns, we built on two settings, one with researchers and one with practitioners. First, we conducted a confirmatory focus group with five research associates and one author as moderator (Tremblay et al., 2010). We selected the participants according to their research field of digital business models. The focus group took 65 min and had three main parts. (1) The moderator explained the goal of this paper and its understanding of the main concepts, such as I4.0 BMs. (2) The group discussed the BM taxonomy and all its elements. (3) The group discussed the BMPs including definitions and examples. The focus group was recorded, transcribed, and analyzed (Tremblay et al., 2010). This led to minor changes in the taxonomy's elements, such as rearranging the elements of one dimension in existing ones and renaming and removing some elements. Second, we used the BMPs in three commercial research projects, where we co-designed I4.0 BMs for three industry incumbents. The project team used the BMPs to support creativity and inspiration for new I4.0 BMs and developed several BM ideas for each of the three established firms. The project teams consisted of approximately five managers (e.g., innovation manager, digital marketing manager, or information systems manager) and five researchers (i.e., professor, postdoc, two PhD students, and one master student). In one case, we worked with an established firm operating in the construction industry, an area which barely shows I4.0 BMs. The new BMs and venture ideas that were created based on the BMPs included a software platform connecting all stakeholders in the construction ecosystem (based on product-related platformization), a new digital service model (based on mass customization), and a crowdsourcing platform for developing new solutions (based on crowdsourced innovation). The suggested solutions were well-received and endorsed by the CEO of the organization for further development in-house. In these two ways, we ensured consistency and demonstrated the applicability and usefulness of our taxonomy and BMPs (Bock and Wiener, 2017).

For theoretical evaluation, we used two guidelines: Nickerson et al. (2013) and Rich (1992). First, we used the objective and subjective ending conditions according to Nickerson et al. (2013). All eight objective conditions are met: (1) We could classify all cases with the taxonomy and the patterns, (2) no cases had to be merged or split to fit to the taxonomy or patterns, (3) each characteristic of the taxonomy and each pattern describe at least one case, (4) to classify all cases, no new characteristic or pattern had to be added, and (5) no element had to be merged or split. Finally, (6–8), every taxonomy dimension, characteristic, super-pattern, and sub-pattern is unique. Similarly, all five objective conditions were met (Nickerson et al., 2013): Based on the cases, the taxonomy and patterns are (1) concise, (2) robust, (3) comprehensive, (4) extendable, and (5) explanatory. Second, we used the criteria for organizational taxonomies and classifications according to Rich (1992) to evaluate the identified BMPs. He introduced seven criteria, which are all met by the patterns: (1) The patterns cover a broad range of firms, (2) have a clear meaning for business, and (3) provide sufficient depth to cover real-life phenomena, namely I4.0 firms. (4) The BM literature serves as a theoretical basis, and (5) the taxonomy serves as a means to measure the patterns' characteristics. Finally, based on the cases, (6) the patterns are complete and logical, and (7) recognizable, as they mirror the real world, namely I4.0 BMs. In conclusion, we used two empirical evaluations, one with practitioners and one with researchers, and two theoretical evaluations to demonstrate the applicability and usefulness of the BM taxonomy and BMPs for I4.0.

4. Findings

The 32 identified cases have very different I4.0 initiatives and related

Table 5
Case studies of industry 4.0 business model innovators.

No	Name	Type	Employees	Industry 4.0 Initiative	
				Year	Description
1	Adidas	Sportswear manufacturer	57,000	2015	Customized shoes and flexible smart factory (Speedfactory) with production times of hours
2	Atomic	Winter sports manufacturer	600	2015	Customized skis and local smart factory with lot size of one.
3	AVL	Powertrain manufacturer	9500	2016	Smart service concept including predictive maintenance based on remote monitoring and IoT
4	Caterpillar	Construction equipment manufacturer	98,400	2016	Data analytics platform for predictive diagnostics for remote fleet monitoring based on IoT sensor data
5	Claas – 365Farmnet	Agricultural machinery manufacturer	11,000	2013	Cloud-based software for farm management with IoT-based tracking, partner modules (two-sided platform) and freemium pricing
6	eMachineShop	Machine parts manufacturer	20	2012	Online factory for customized parts (CNC machining, injection molding, and 3D printing)
7	GE Digital	Unit of General Electric	28,000	2015	Cloud-based industrial IoT platform (Predix) and consulting for industrial digital transformation
8	KAESER Compressors	Compressor manufacturer	6000	2006	Selling of compressed air with IoT sensors, remote monitoring, and predictive maintenance
9	Konecranes	Cranes manufacturer	15,500	2015	Remote monitoring and all-inclusive renting
10	Local Motors	Vehicle manufacturer	250	2007	Rapid digital development and production with developer community and 3D printing
11	Ponoko	Online service for manufacturing	12	2007	On-demand, distributed, digital manufacturing platform connecting designers, fabricators, suppliers, and buyers
12	Shapeways	3D-printing platform	200	2007	Product 3D printing service, online-shop and community for entrepreneurs and designers
13	Texa CARe	Diagnostic tools manufacturer	640	2017	IoT device to remotely monitor cars and automatic emergency alerts using a freemium model
14	TRUMPF – AXOOM	Machine tool manufacturer	100	2015	Trading platform for machine tool process parameters and consulting for digital transformation
15	Zumtobel	Light solutions manufacturer	6200	2016	IoT-based, intelligent, and energy-efficient light solutions using continuous revenues
16	ABB Marine Systems	Ship engine manufacturer	147,000	2013	Remote monitoring and diagnostics with IoT sensors using service contracts
17	ABT Power Management	Battery management service provider	~100	2002	Remote monitoring of forklift batteries and offering of guaranteed power supply for forklifts
18	Biesse Group	Machine manufacturer	3800	2017	IoT platform for remote performance monitoring offered with a pay-per-use model
19	Bosch Engineering	Electronic system provider	2000	2015	Condition monitoring for rail freight transportation, based on IoT device attached to freight (AMRA)
20	Daimler Mobility Services	Vehicle manufacturer	1000	2008	Free-floating car rental on a pay-per-use model (Car2Go), mobility services platform (Moovel)
21	GE Fuse	3D printing service	5–100	2016	Rapid-prototyping and small-batch manufacturing with 3D printing based on crowdsourcing
22	GE Taleris	Engine service provider	50–200	2013	Predictive maintenance for jet engines and fleet optimization services for airlines based on IoT
23	Hilti	Construction tool manufacturer	28,000	2014	Tools on demand with guaranteed availability (Fleet Management) and cloud-based asset management (ON!Track)
24	Michelin	Tire manufacturer	112,000	2013	IoT sensors and platform to track and monitor trucks fleets and optimize fuel costs (EFFIFUEL)
25	New Balance	Footwear manufacturer	5000	2013	Automated smart factory based on IoT sensors with 3D printing and customization
26	Pirelli	Tire manufacturer	30,000	2017	IoT sensors and platform to monitor tire conditions and reserve garage appointments (Conesso)
27	Rolls-Royce	Aero-engines manufacturer	1300	2002	Power-by-the-hour business model (since 1962) and IoT sensors to remotely monitor engines
28	Samudra LED	Light solutions manufacturer	10–50	2015	Remote monitoring and control of lights for optimizing energy efficiency based on IoT
29	Schlotterer	Sun protection manufacturer	440	2011	Automated, customized, on-demand production with a lot size of one directly communicating with online shop
30	Siemens	Industrial manufacturer	379,000	2016	Renting of drive technologies with guaranteed availability based on remote monitoring
31	ThyssenKrupp Elevator	Elevator manufacturer	50,000	2014	Remote monitoring and predictive maintenance based on IoT sensor data
32	Würth Industrie Service	Logistics provider	1500	2013	Intelligent Kanban box (iBin) monitors inventory levels and automatically orders, if needed

BMs. Table 5 provides an overview of the general characteristics of the cases and their I4.0 initiatives.

4.1. Taxonomy for industry 4.0 business models

The derived taxonomy for I4.0 BMs consists of five meta-dimensions and 19 dimensions with two to six distinct characteristics each (see Table 6). Marked characteristics (*) refer to the extensive list of BMPs of Remané et al. (2017b). Complete I4.0 BMs are combinations of the taxonomy's characteristics. Thus, not every single characteristic is new in I4.0. However, these characteristics are needed to comprehensively describe I4.0 BMs.

The 19 dimensions show common characteristics of I4.0 BMs. The dimensions of market and segments highlight how I4.0 can change target markets and customer segments, as seen in the case of Texa. The value proposition strategy shows new directions of I4.0 BMs. The dimension of factory of the value chain emphasizes that in I4.0 some firms step back from mega-factories and transform into several local micro-factories, as seen in the cases of Adidas, Local Motors, Shapeways, and Ponoko. The dimension of platform captures different types of I4.0 platforms. The value capture dimension differentiates between revenue (how?) and sales models (what?). Hence, it distinguishes between innovative ways to generate revenues (e.g., freemium or usage-based) and parameters that determine the payment amount (e.g., usage or result of a product).

4.2. Business model patterns for industry 4.0

We identified three super-patterns and 10 sub-patterns of I4.0 BMs. The super-pattern *integration* innovates its BM around new processes, *servitization* around new products, and *expertization* around a hybrid of products and processes. The case studies illustrate the I4.0 BMPs and their relations. Table 7 gives an overview of the patterns. Table A2 in the appendix provides more details.

4.2.1. Integration – process-focused business model

Integration BMPs aim to cover more parts of the value chain (Remané et al., 2017b). Firms adopting this BMP typically transform from specializing on a single step of the value chain toward covering more activities. Thus, new processes rather than completely new products are the basis for this BMP. The super-pattern integration has three sub-patterns: *crowdsourced innovation, production as a service***,** and *mass customization*.

The three sub-patterns have in common that the meta-dimension value chain indicates most of the changes. Firms open their innovation processes by integrating customers or development communities in development processes. Smart production converts the production process from push to pull and relocates production facilities from centralized mega-factories in low-wage countries to decentralized production in micro-factories close to the local markets, even in high-wage countries. New production techniques allow for small batch sizes, shifting mass production toward mass customization or even mass individualization. Moreover, shifts in key elements and target customers characterize this super-pattern. Online channels allow firms to directly sell to customers and replace distributors.

4.2.1.1. Crowdsourced innovation. A new product development and design process shapes *crowdsourced innovation*. A community of people design products (crowdsourcing) instead of hired experts only. The innovation platform becomes a key resource and the community a crucial partner. Firms move from a closed business toward an open one. New manufacturing techniques allow fast, on-demand production of individual goods in micro-factories (mass individualization). The car manufacturer Local Motors, for example, announces challenges for car engineering on its innovation platform Launch Forth and members can submit suggestions. Local Motors prints cars directly from the digital specification files in its micro-factories.

4.2.1.2. Production as a service. Transforming product ideas into physical goods is core to *production as a service*. Firms undertake production from design checking until shipping as a service for their customers. The value chain shifts from producing mass-produced, expert-designed goods to mass-individualized, user-designed products. The customer becomes a key partner and can choose among a wide range of different materials and production techniques (long tail). Philips Electronics' spin-off Shapeways.com, for example, is a platform for 3D-printed consumer goods. The firm offers a product printing service, an online shop, and a designer community. Designers can upload their 3D design, select materials, and sell products via the online shop. When receiving an order, Shapeways.com builds the product on-demand nearby the final destination and ships it to the customer.

4.2.1.3. Mass customization. The integration of customers into the value chain characterizes *mass customization*. Firms shift from mass production to mass customization, which enables customers to adapt the final product to their individual taste by choosing from a range of options (long tail). However, hired experts and designers still develop and design the core product. Customization is an additional option for personalization only and not a requirement (add-on). Smart production enables profitable production of small lot sizes. For example, Adidas's customers can personalize shoes in its online shop by changing colors or adding individual letters or logos.

4.2.2. Servitization – product-focused business model

Integrating sensors into products (digitally charged products (Fleisch et al., 2014)) enables the super-pattern of servitization to provide new PSS instead of selling solely tangible products. Offering remote monitoring or predictive maintenance services for products turns these firms into solution providers. Thus, new offerings rather than new processes are the basis for this BMP, steering customers' production toward smart production. The sub-patterns are an implementation of known PSS types in I4.0 (Reim et al., 2015; Tukker, 2004).

4.2.2.1. Life-long partnerships. IoT-connected products enable this pattern to evolve a firm's service portfolio from scheduled maintenance with repairs after failure to preventing breakdowns with remote monitoring and predictive maintenance throughout the whole product lifecycle. The firm becomes a solution provider and a partner for the entire product use phase. A firm still generates significant turnover by selling tangible products. However, firms add continuous revenue streams with subscription-based, life-long service contracts. AVL List, for example, is a leading provider of tailored powertrain development and test system solutions. The firm offers remote usage and condition monitoring in addition to product sales and aims to optimize product lifetime. They proactively exchange weak parts to avoid breakdowns.

4.2.2.2. Product as a service. Renting instead of selling products and related services or offering them for a use-based fee shapes this sub-pattern. Customers do not pay for ownership or service delivery but for product usage and availability. Smaller but continuous fees replace higher proceeds of one-time product sales. This sub-pattern provides new customer value by guaranteeing the availability of the product. Konecranes, for example, not only sells industrial cranes but also rents them out with remote monitoring and predictive maintenance services based on a monthly fee.

4.2.2.3. Result as a service. Selling the output or result of a product characterizes *result as a service*. Like product as a service, it turns discontinuous sales-based revenue streams into continuous ones. Firms sell full-service packages and take responsibility for safe operations and

Table 6
Taxonomy of industry 4.0 business Models.

Marked characteristics (*) based on Remané, Hanelt, Tesch, et al. (2017)

Meta-Dim.	Dimensions	Question	Characteristics					
Target Customers (Who)	Market	To which market does the firm sell?	B2B only (22)	B2C only (6)	B2B & B2C (4)	Multi-sided market * (8)		
	Segments	Does the firm target new customer segments due to the I4.0 transformation?	Existing customer segment only (13)	New customer segment only (8)	New and existing customer segment (11)			
	Contact	How does the firm interact with its customers?	Hybrid (intermediary and direct) (4)	Direct selling * (28)				
	Channel	Which channel is used for interacting with customers?	Offline (7)	Bricks & clicks * (20)	Online * (5)			
Value Proposition (What)	Strategy	Which general value proposition strategy does the firm use?	Add-on * (10)	Lock-in * (15)	Aikido * (5)	Make more of it * (12)		
	Product	What is the good the firm produces and makes money with?	Physical only (10)	Physical, digitally charged * (19)	Digital only (10)			
	Service	What is the content of the service offering?	Repair & maintenance (2)	Monitoring & predictive maintenance * (17)	Product (9)	Production (3)	IT (9)	Advice & consulting * (8)
Value Chain (How)	Development & Design	Who develops and designs the products that the firm sells?	Hired or employed experts (16)	Customer/ user designed * (3)	Development community/ crowdsourcing * (4)			
	Customization	How individualized is the product?	Mass production (7)	Mass customization * (14)	Mass individualization (5)			
	Push/Pull	What kind of production paradigm is used?	Pull/ on-demand * (8)	Push and Pull (1)				
	Factory	What is the size of the operating factories?	Mega-factory (4)	Micro-factory (5)				
	Role	Which role of the value chain does a firm focus on?	Integrator * (9)	Service and support * (20)	Intermediary * (6)			
Key Elements (How)	Key Partners	Which partnerships are essential to delivering the proposed value?	Inside-sector partners (6)	Outside-sector partners (5)	Customer or community including customization * (14)			
	Data Analytics	Where does the high-value data come from?	Internal data (4)	Customer's data * (21)				
	Key Employees	Which is the most characteristic job of the value creation and delivery process?	Operator & maintainer (15)	Remote monitoring (19)	Software developer & IT (10)	Consultant or trainer * (8)		
	Platform	What kind of digital platform is an essential part of the BM, if any?	IoT (21)	Merchant only (3)	Innovation * only (2)	Merchant & innovation (3)		
Value Capture (Why)	Revenue Model	How does the firm generate and manage revenues?	Sales * (24)	Revenue sharing * (2)	Freemium * (4)	Rent/ lease * (4)	Subscription * (18)	
	Continuity	How continuous are the revenues?	Once (10)	Mixed (16)	Continuous (12)			
	Sales Model	What does the customer pay for?	Ownership/ service delivery (24)	Use/ availability (11)	Result (3)			

The number in brackets indicates the number of cases that apply this characteristic.

Table 7
Business model patterns for I4.0.

Super-patterns	Sub-patterns			
Integration (9)	Crowdsourced innovation (2)	Production as a service (3)	Mass customization (6)	
Servitization (18)	Life-long partnerships (12)	Product as a service (6)	Result as a service (3)	
Expertization (13)	Product-related consulting (5)	Process-related consulting (3)	Product-related platformization (5)	Process-related platformization (5)

The number in brackets indicates the number of cases that apply this business model pattern.

compliance. KAESER, for example, innovated from selling compressors to selling compressed air per cubic meter with its I4.0 offering Sigma Air Utility. In contrast to KAESER's product as a service solution Sigma Flex, KAESER takes full responsibility and operates compressors at the customer's site.

4.2.3. Expertization – hybrid business model

This super-pattern uses a firm's internally built expertise in products or processes (make more of it) and offers it as a new consulting service (*product-related* and *process-related consulting*) or a new platform-based product (*product-* and *process-related platformization*) (see Fig. 2).

4.2.3.1. Product- and process-related consulting. The consulting sub-patterns shift the value chain focus from production toward service and support. Both patterns transform the meta-dimensions of value proposition, key elements, and architecture. Value capture, value chain, and target customers are not affected. Firms still focus on one-time sales of services in addition to manufacturing and selling tangible products. The consulting sub-patterns interact with existing B2B customers directly and offline.

Product-related consulting complements product sales with advice and consulting based on the firm's own experiences with the products. The type of product can range from purely physical to purely digital products. Firms provide new customer value by offering integrated product service solutions. The new consulting service extends the existing product/service line or is an add-on to it. Firms help their customers to make optimal use of the products. In contrast, servitization patterns focus on repair, maintenance, or operating services and not on consulting. KAESER, for example, makes use of its expertise in compressors by offering tailored system planning and consulting services for energy-saving.

Process-related consulting makes use of a firm's experiences in internal processes. Firms offer this know-how to external parties as advice and consulting. This new service does not involve a tangible product and contains new value beyond the traditional value proposition (do more to address the job), for example, consulting about smart production and digital transformation. For example, GE Digital provides consulting about digital transformation, making use of GE's own experiences. Michelin uses its experience with tires to provide advice and consulting on fuel consumption and eco-driving.

4.2.3.2. Product- and process-related platformization. The platformization patterns offer a new platform-based, digital product together with complementary IT services. Firms move from producing and selling physical products with at most product-related services toward digital products with related IT services. This requires employees with software development and IT skills. Customer contact takes place directly both, online and offline. I4.0 digitally upgrades pure offline channels. The new offerings address both, existing and new customer segments. The meta-dimension of value capture moves from one-time sales to continuous subscription fees, in which customers do not pay for the ownership of a physical product but for its availability. The meta-dimension value chain shifts from mass production of physical products toward mass customization of digital products. External developers thereby play a more important role in product development and design.

Product-related platformization describes how firms use their experience from manufacturing and selling asset-intensive machinery and turn it into a new digital product. The new offering primarily addresses unsolved customer problems (do more to address the job). In the case studies, the new product is a cloud-based platform for innovating or trading goods and services among user groups. Community members become key partners. Acting as an intermediary in this multi-sided market allows firms to charge different user groups, for example, commissions from third parties. Claas, for example, extends its business scope from manufacturing and selling farm machinery to a cloud-based software solution for farm management with its spin-off, 365Farmnet. Other firms can also offer modules for 365Farmnet. Thus, Claas uses the IoT data from tractors and addresses further pain points of its customers, such as farm management, crop planning, and paperwork.

Process-related platformization makes use of a firm's experience with internal processes and smart production and transforms it into a new digital platform with related services, for example, an IoT platform. In contrast to product-related platformization, the value proposition is an integrated solution of a digital product and related IT services rather than solving other customer's problems. Firms are more focused on service and support rather than intermediating. Analyzing customers' data becomes a key activity, while a user community is less relevant. The GE Software Center, for example, developed the IoT platform Predix as an internal solution for machine operators and maintenance engineers. It aimed to reduce GE machine downtimes and to schedule maintenance checks more profitably (Schaefer et al., 2017; Winnig, 2016). Due to continuous product improvement and market demand, they used their platform knowledge and offered the more open industrial IoT platform: Predix 2.0.

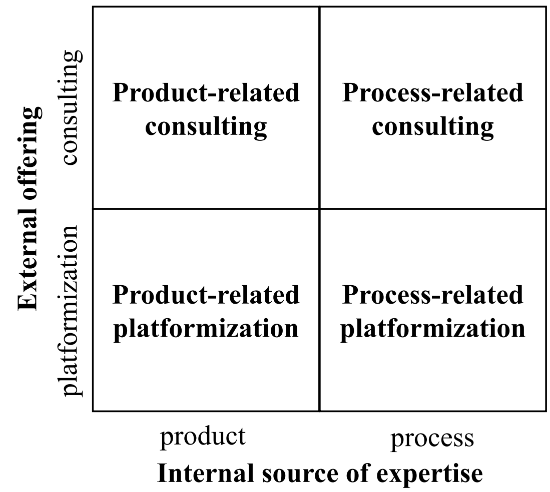

Fig. 2. Expertization sub-patterns.

5. Discussion

Despite the importance of manufacturing firms transforming toward I4.0 BMs, research has focused on the technological aspects. Little research addresses I4.0 BMs. Therefore, we investigate BMPs for I4.0. We analyzed 32 case studies of firms that have transformed towards I4.0 BMs and developed a taxonomy and 13 patterns to characterize I4.0 BMs.

5.1. Supporting technologies and concepts

The taxonomy and BMPs show different ways how firms can leverage I4.0 technologies and concepts to yield competitiveness. In the following, we discuss the relation of OI, mass customization, PSS and IoT with the taxonomy and the 13 BMPs.

The taxonomy and patterns show how open innovation and mass customization can be leveraged. For outside-in OI, the taxonomy shows that firms can build their value chain on a development community or crowdsourcing, and that partners, customers, or a community can become key partners, resulting in an open BM. Further, the taxonomy identifies two forms of customization, that is, mass customization and mass individualization. The BMPs crowdsourced innovation and mass customization show how firms can respond to customers' demand for individualized products and active participation (Djelassi and Decoopman, 2013). The BMP of mass customization directly builds on the identically named concept. Online shops enable direct communication with a smart factory (Bullinger and Schweizer, 2006; Grimal and Guerlain, 2014), which allows for efficient mass production of individual products on demand. For inside-out OI, the characteristics of advice and consulting services, production as a service, or make more of it in the taxonomy and expertization patterns illustrate how firms can benefit from offering internal know-how externally. Hence, OI and mass customization support I4.0 BMs in different ways.

The taxonomy shows several ways for utilizing PSS. The dimensions of value proposition, service offering, and revenue and sales models reveal different ways to profit from PSS in I4.0. Besides, the three patterns of servitization, that is, life-long partnerships, product as a service, and result as a service demonstrate how to exploit the three general types of PSSs (Tukker, 2004). Thus, I4.0 and related technologies, such as IoT, are closely linked to servitization and PSS, and foster these PSS BMs.

The taxonomy reveals many options for how to leverage IoT with I4.0 BMs. Firms can offer monitoring and predictive maintenance, guaranteed availability, product or even production as a service, building on IoT, and become a solution provider or full-service operator. Moreover, providing an IoT platform enables partners to offer these services (Hein et al., 2019; Hein et al., 2018). All 13 patterns provide distinct BMs that profit from IoT. Integration patterns illustrate how IoT devices work as CPS in a provider's smart factory and enable efficient production. Servitization patterns leverage IoT devices as CPS to support a smart factory at the customer's site. Additionally, IoT enables servitization itself with remote monitoring and predictive maintenance. Expertization patterns show how providers can learn from IoT data, and offer this know-how externally (i.e., product- and process-related consulting), create a market for IoT data (i.e., product-related platformization), and connect IoT devices (i.e., process-related platformization) (Hein et al., 2019). Thus, IoT is an important foundation for I4.0 BMs and can be exploited in different ways.

5.2. Theoretical implications

This research contributes to the literature by showing what I4.0 really means for BMs and what important elements a BM under I4.0 should have. This has important implications for the literature on production economics and BMs.

5.2.1. Production economics and management literature

We contribute to production economics in three ways. First, we develop a taxonomy for describing, analyzing, and classifying BMs for I4.0. General BM frameworks or general BM patterns do not cover the complexity and specific characteristics of the manufacturing and I4.0 context (Gassmann et al., 2014; Osterwalder and Pigneur, 2010; Remané et al., 2017b; Taran et al., 2016). These frameworks provide a high-level structure, that is, four dimensions of BMs, whereas our taxonomy implements this structure and further considers detailed contextual design elements, that is, 19 dimensions with two to six characteristics each. Moreover, we derive 13 archetypal BMPs for I4.0. In this way, we respond to the call of Zott et al. (2011) to generate BM typologies for specific industries. Thus, we are able to build on all three levels of BMs: BM elements (taxonomy), BM patterns describing common configurations of the elements, and instances of real firms. With this use, the BM concept is most powerful (Osterwalder et al., 2005).

Second, we explain how I4.0 impacts BMs, service systems, and the roles of manufacturing firms. Whereas prior research mainly focused on technological implications (Burmeister et al., 2016; Kiel et al., 2016) and lacked BMs and their emerging roles for manufacturing firms, this paper reveals how I4.0 leads to new BMs and new service systems for manufacturing firms. The taxonomy for I4.0 BMs shows how I4.0 changes BMs and the role of manufacturing firms in their ecosystems. The 13 BMPs illustrate new roles of manufacturing firms. Additionally, the results reveal new service systems. All 13 patterns show different forms of service systems and value co-creation, and illustrate how new services provide customer value. Patterns indicate strategies for enabling value co-creation in an industrial setting and illustrate how I4.0 and related new digital technologies affect service systems.

5.2.2. Business model literature

This study contributes to the BM literature in two ways. First, the results contribute to the growing field of enterprise classifications based on BMs (Täuscher and Laudien, 2018). In the context of I4.0, the extant literature does not structure strategic options and BMs. The taxonomy as a common vocabulary facilitates the systematic description and the intuitive knowledge of I4.0 BMs, and opens options for I4.0 BMI without oversimplifying their complexity. Moreover, the 13 archetypal BMPs structure I4.0 BMs and support their classification. We follow the call for analyzing pattern-based BMI in industries under change with existing BMP collections as the basis for our taxonomy (Remané et al., 2017b). Further, we shed some light on the understudied topic of how to make traditional BMs fit for new technologies and, specifically, for I4.0 (Bock and Wiener, 2017; Grünert and Sejdić, 2017; Johnson et al., 2008).

Second, our research method illustrates how to derive an industry-specific BM taxonomy, and shows BMPs utilizing case study, case survey, and taxonomy development approaches as guidelines. Case studies provide extensive and in-depth analyses (Yin, 2014), whereas case surveys show generalizable, cross-sectional analysis (Larsson, 1993). Taxonomy development adds a systematic approach to structuring and interpreting empirical findings as well as integrating conceptual research (Nickerson et al., 2013). One technique was to distinguish cases by the richness of their information. We use cases with rich information for building the taxonomy patterns, and build on cases with less information for one evaluation of the taxonomy and patterns. Finally, we use four approaches to evaluate both results. By building on these methods, we show how to systematically derive an industry-specific BM taxonomy and BMPs. The results show both in-depth information and generalizability for a specific industry. We again build on all three levels of BMs: real-world instances (cases), BM elements (taxonomy), and patterns (Osterwalder et al., 2005) and leverage the full potential of BMs.

5.3. Practical implications

For practice, this paper addresses the lack of guidance for BMI under I4.0 (Laudien and Daxböck, 2016). We show what new BMs under I4.0 look like (Sarvari et al., 2018) and guide firms in leveraging I4.0, including its technologies and concepts, such as OI, mass customization, PSS, IoT, CPS, and smart factories. Practitioners can characterize their current BM by using the taxonomy to assess its I4.0 readiness. Moreover, characterizing their BM with the taxonomy supports inspiration. Each dimension provides opportunities for transforming toward I4.0 in terms of characteristics and related cases. The characteristics and case examples allow managers to discover opportunities for progressing BMIs toward I4.0 and directly communicate new ideas with the taxonomy. Similarly, the taxonomy can be used to analyze competition, compare BMs, and identify white spots in the market. The 13 patterns further provide inspiration for I4.0 BMIs and case examples for I4.0 BMs. Similar to Gassmann et al. (2014), practitioners can use patterns and underlying cases in an ideation phase to support thinking out of the box. To stimulate creativity, practitioners can use questions such as: What would our firm look like when applying the pattern result as a service? Organizations can further assess the implementation of the pattern in the firm's context because each pattern specifies the BM dimensions it affects most. Overall, the taxonomy and patterns support communicating and modelling new ideas and the current BM, and stimulate creativity and inspiration with the taxonomy's characteristics, BMPs, and related cases.

5.4. Limitations

Our study faces some limitations. First, the taxonomy and the archetypal BMPs are based on and dependent on the 32 case studies. BMs and technologies innovate quickly. We could only consider cases that were available when we wrote the paper. We only searched and considered German and English cases due to language barriers. It would be interesting to investigate BMIs that resulted from governmental initiatives comparable to Industry 4.0 of other countries such as the Chinese *Made in China (2025)* or the French *La Nouvelle France Industrielle.* Second, the qualitative approach may restrict our findings. We developed both, the taxonomy and the BMPs, by building on a qualitative content analysis of data from existing case studies and secondary data. Therefore, it was a challenge to conduct the analysis objectively. However, Nickerson et al. (2013) have already noted that taxonomies are never perfect, but exist to provide an appropriate solution in a specific context. Third, from a practical perspective, BMI must be aligned with a firm's strategy and its competitive landscape. Successful BMI requires both expertise and creativity (Remané et al., 2017b). Managers should avoid superficial analogies (Gavetti and Rivkin, 2005). Thus, our findings are a starting point for BMI; however, managers must carefully evaluate their firm's context before applying these BM patterns (Abdelkafi et al., 2013).

5.5. Future research

Our research enables several avenues for future research. Rich taxonomies and typologies are the basis for theory building (Doty and Glick, 1994; Rich, 1992). Future research can build on our taxonomy as well as archetypal BMPs to develop theories. The taxonomy and the patterns provide a solid foundation for qualitative as well as quantitative studies. Qualitative research can analyze patterns or specific dimensions of the taxonomy regarding their success factors and key challenges. Quantitative studies can analyze BMPs or specific dimensions or configurations of the taxonomy concerning their market performance (similar to Weill et al., 2011), their profitability, or their influence for competitive advantage in different contexts. Moreover, future research can investigate the dominant transition paths from one pattern or taxonomy configuration to another. Furthermore, the taxonomy and patterns can be extended toward an I4.0 maturity model.

6. Conclusion

I4.0 as smart production enabled by the IoT, CPS, and smart factories, bears great potential for manufacturing firms to secure competitiveness and seize upcoming opportunities (Rabetino et al., 2017; Wei et al., 2017). However, applying new technologies is often not enough to succeed, additionally, a sustainable BM is needed (Abdelkafi et al., 2013). Still, especially for I4.0, extant research has mainly focused on technological questions and neglects BMs (Burmeister et al., 2016; Kiel et al., 2016). Thus, manufactures do not know how to innovate their BM toward I4.0 (Grünert and Sejdić, 2017).

Therefore, this paper analyzes I4.0 BMs and derives I4.0 BMPs to provide guidance for manufacturers and connect the technical-driven I4.0 literature with the BM research. We collected 32 case studies about I4.0 BMs from literature and practitioner reports. For data triangulation (Yin, 2014), we enrich the case description with information from the firm websites, newspaper articles, publicly available interviews and press releases. Based on these case studies, we develop a taxonomy for I4.0 BMs consisting of 19 dimensions with two to six characteristics each (Nickerson et al., 2013). By applying the taxonomy to the case studies, we derive 13 archetypal patterns of I4.0 BMs.

The taxonomy and 13 patterns cover specific characteristics of I4.0 and can describe, analyze, and classify related BMs. The patterns are a first step toward a classification schema and a common language for I4.0 BMs. They deepen the understanding of how I4.0 impacts ecosystem roles, BMs, and service systems, and show how firms can leverage I4.0 concepts. Thus, they provide structure and accelerate the development of I4.0 BMs (Bocken et al., 2014). Practitioners can use our results to evaluate the I4.0 status of their current BM and draw inspiration for possible BMI opportunities toward I4.0. Future research can build on this typology of I4.0 BMs for theory-building and further investigate the digitization of manufacturing firms.

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Appendix A. Sources of Case Studies

Table A1
Analyzed Sources of Case Studies

No	Firm	Main empirical study	No. of sources	Further sources
1	Adidas	Plattform-i40 (2017)	11	(Adidas, 2015, 2017; 2018; BMWi, 2018; Köhn, 2016; Plattform-i40, 2017; Stadler, 2015; Weitzenbürger, 2016; Wiener, 2017; Zühlke, 2015)
2	Atomic	Lassnig et al. (2017)	5	(Atomic, 2018; Industrie-4.0-Österreich, 2018a; Sportaktiv.com, 2017; Wörndle, 2015)
3	AVL	Lassnig et al. (2017)	4	(AVL, 2017; Industriemagazin, 2016, 2017)
4	Caterpillar	Schaefer et al. (2017)	5	(Caterpillar, 2015, 2018; Crain's Chicago Business, 2015; UPTAKE, 2018)
5	Claas – 365Farmnet	Bauernhansl et al. (2015)	7	(365FarmNet, 2018; Brisslinger, 2016; CLAAS, 2017, 2018; Daugherty et al., 2015; Sentker, 2015)
6	eMachineShop	Bauernhansl et al. (2015)	4	(Businesswire.com, 2004; eMachineShop, 2018; Marketwired.com, 2006)
7	GE Digital	Schaefer et al. (2017)	7	(Bloomberg, 2016; GE, 2018a; Gutowski, 2017; Moazed, 2018; Predix.io, 2018; Winnig, 2016)
8	KAESER Compressors	Kaufmann (2015)	6	(Bonnen, 2017; Etscheit, 2017; Kaeser.com, 2017; Nuissl, 2015; T-Systems.com, 2017)
9	Konecranes	Wortmann et al. (2017)	5	(Konecranes, 2016, 2018; Weinberger et al., 2016, p. 704; Wirtschaftsforum.de, 2018a)
10	Local Motors	Bauernhansl et al. (2015)	7	(Crunchbase, 2017; Kilimann, 2015; Kumar, 2016; Launchforth.io, 2017; Local Motors, 2017; McKinsey, 2015)
11	Ponoko	Gassmann et al. (2014)	4	(David, 2014; McGahan, 2012; Ponoko.com, 2018)
12	Shapeways	Bauernhansl et al. (2015)	5	(3D-Grenzenlos, 2017; Estes, 2014; Shapeways, 2017; Smith, 2012)
13	Texa CARe	Microsoft (2017a)	4	(Texa, 2018a, 2018b; Wirtschaftsforum.de, 2018b)
14	TRUMPF - AXOOM	Grünert and Sejdić (2017)	7	(AXOOM, 2017; Feil, 2017; I40-bw.de, 2017; Nowak, 2017; TRUMPF, 2017; Weinzierl, 2015)
15	Zumtobel	Lassnig et al. (2017)	4	(Industrie-4.0-Österreich, 2018b; Strölin, 2016; Zumtobel Group, 2018)
16	ABB Marine Systems	Wortmann et al. (2017, p. 12)	2	ABB (2018)
17	ABT Power Management	Microsoft (2018)	2	ABT (2018)
18	Biesse Group	Accenture (2018)	2	Biesse (2018)
19	Bosch AMRA	Wortmann et al. (2017, p. 12)	3	(Bosch, 2015, 2018)
20	Daimler Mobility Services	Bauernhansl et al. (2015)	8	(Bay, 2017; Car2Go, 2018; Daimler, 2017, 2018; Daugherty et al., 2015; Howard, 2016; Moovel, 2018; Muoio, 2017)
21	GE Fuse	BCG (2017)	6	(Alpaio; Davies, 2017; Davis, 2017; GE, 2016; Kloberdanz, 2017; Scott, 2016)
22	GE Taleris	Daugherty et al. (2015)	4	(Foster, 2013; GE, 2013, 2018b)
23	Hilti	Wortmann et al. (2017, p. 12)	7	(Gassmann et al., 2014, p. 48f.; Hilti, 2015a, Hilti, 2015; 2018; Meisterteam.de, 2018; vom Brocke et al., 2017)
24	Michelin	Daugherty et al. (2015)	4	(Bremmer and Hill, 2017; Michelin, 2018; Schmidt, 2015)
25	New Balance	BCG (2017)	4	(Lukic, 2017; New Balance, 2018a, 2018b)
26	Pirelli	Schaefer et al. (2017)	6	(Pirelli, 2016a, 2016b; 2017a, 2017b, 2018)
27	Rolls-Royce	Microsoft (2016)	4	(Frank, 2014; Gassmann et al., 2014, pp. 9, 200f.; Rolls-Royce, 2018a, 2018b)
28	Samudra LED	Microsoft (2017b)	3	(IFC, 2017; Samudra, 2018)
29	Schlotterer	Lassnig et al. (2017)	5	(BLINOS, 2018; Elsässer, 2016; Schlotterer, 2018; Tagesspiegel, 2017)
30	Siemens	Plattform-i40 (2018)	1	–
31		Microsoft (2014)	2	ThyssenKrupp (2018)

(continued on next page)

Table A1 (*continued*)

No	Firm	Main empirical study	No. of sources	Further sources
	ThyssenKrupp Elevator			
32	Würth Industrie Services	Bauernhansl et al. (2015)	5	(Konzany, 2015; Würth, 2016a; 2016b, 2018)

Appendix B. Business Model Patterns of Case Studies

Table A2
Relation of Case Studies and Business Model Patterns for Industry 4.0

Super-Patterns		Integration			Servitization			Expertization			
Case Studies		Sub-Patterns									
		Crowdsourced Innovation	Production as a Service	Mass Customization	Life-long Partnerships	Product as a Service	Result as a Service	Product-related Consulting	Process-related Consulting	Process-related Platformization	Product-related Platformization
10	Local Motors	X									X
21	GE Fuse	X									
6	EMachineShop		X								
12	Shapeways		X	X							
11	Ponoko		X	X							
1	Adidas			X							
2	Atomic			X							
25	New Balance			X							
29	Schlotterer			X							
3	AVL				X						
4	Caterpillar				X						
13	Texa				X						
16	ABB Marine				X						
22	GE Taleris				X						
28	Samudra LED				X						
31	ThyssenKrupp				X						
32	WIS				X						
9	Konecranes				X	X		X			
8	KAESER				X	X	X	X			
18	Biesse				X					X	
7	GE Digital				X				X	X	
20	Daimler					X		X			X
27	Rolls-Royce					X					
30	Siemens					X					
24	Michelin					X			X		
17	ABT Power						X				
15	Zumtobel						X	X			
23	Hilti							X		X	
19	Bosch									X	
14	TRUMPF								X	X	X
5	CLAAS										X
26	Pirelli										X

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Appendix E. The Impact of Blockchain Technology on Business Models – A Taxonomy and Archetypal Patterns (P5)

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RESEARCH PAPER

The impact of blockchain technology on business models – a taxonomy and archetypal patterns

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Abstract
Blockchain technology enables new ways of organizing economic activities, reduces costs and time associated with intermediaries, and strengthens the trust in an ecosystem of actors. The impact of this seminal technology is reflected by an upcoming research stream and various firms that examine the potential uses of blockchain technology. While there are promising use cases of this new technology, research and practice are still in their infancy about altering existing and creating new business models. We develop a taxonomy of blockchain business models based on 99 blockchain ventures to explore the impact of blockchain technology on business models. As a result, we identify five archetypal patterns, which enhance our understanding of how blockchain technology affects existing and creates new business models. We propose to use these results to discover further patterns fueled by blockchain technology and illustrate how firms can use blockchain technology to innovate their business models.

Keywords Blockchain · Business model · Design science · Taxonomy · Pattern · Platform

JEL classification O3

Introduction

Blockchain is a contemporary technology with the potential to build a foundation for creating unprecedented business models (Iansiti and Lakhani 2017). Of particular interest are business models that remove intermediaries in an ecosystem of actors and those that foster security over performance (Lacity 2018). This change in a ventures' business models adversely impacts several industries (Kshetri 2018; Wang and Kogan 2018). Existing blockchain solutions in the financial industry, for example, eliminate the need for reconciliation and intermediation and enable direct transactions between trading partners (Short 2018). In addition, blockchain technology enables its participants to continuously trace their assets and settle transactions autonomously while providing a secure model that is fault-tolerant, resilient, and permanently available. Upcoming blockchain solutions, such as VeriPart from Moog in the manufacturing industry, facilitate enhanced security and resilience features to increase trust in 3D-printed parts. Inspired by those firms and the expectation for added business value, an increasing number of organizations are actively considering blockchain technology to be a foundational technology (Lacity 2018; Iansiti and Lakhani 2017). In sum, blockchain technology helps authenticate traded goods, facilitate disintermediation, and improve operational efficiency, thereby influencing existing and creating new business models (Nowiński and Kozma 2017).

Whereas the impact of blockchain technology on business models is important (Lacity 2018), current research predominantly focuses on technological aspects (Nakamoto 2008; Wang and Kogan 2018; Eyal and Sirer 2018) and its

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application in practice (Kshetri 2018; Jun and Vasarhelyi 2017; Radanović and Likić 2018). Examples illustrate the transformation process (Ying et al. 2018; Y. Chen 2018) and indicate how blockchain technology can potentially alter processes and service provision within different industries. However, to the best of our knowledge, no empirical-based research exists regarding how blockchain technology can both change existing and build the foundation for new business models.

In addition to a lack of theoretical focus on the influence of blockchain technology on business models, blockchain companies still fail to deliver the promised business value. Firms lack an understanding of how blockchain technology can create business value for their respective business model (Lacity 2018). Furthermore, it remains unclear what business model patterns have proved to be already successful for this new foundation technology. Building on those shortcomings, this paper focuses on the following research questions:

> *Research Question 1: How can blockchain business models be classified in a taxonomy?*
> *Research Question 2: What are archetypal business model patterns for blockchain technology?*

To address these questions, we use design science research to develop a taxonomy for blockchain business models and to extract archetypal patterns (Gregor and Hevner 2013). First, we establish a theoretical understanding by conducting a literature review (Webster and Watson 2002) of business models and blockchain technology. Next, we sample a broad database of 99 firms that utilize blockchain technology. We iteratively combine the empirical data with the results of the literature review to develop a business model taxonomy (Nickerson et al. 2013). The blockchain business model taxonomy follows the conceptual representation of business models (Massa et al. 2017). We end by evaluating the ending conditions of taxonomy development (Nickerson et al. 2013). Second, we perform a cluster analysis (Kaufman and Rousseeuw 2009; Struyf et al. 1997) of the blockchain business model taxonomy based on prior theoretical contributions and the database to derive archetypal patterns as reoccurring successful traits (Weking et al. 2018a). We conclude the cluster analysis by evaluating the resulting five patterns using Fisher's exact test (Fisher and Bennett 1990) to confirm that the patterns significantly differ from one another.

Related work

Business models

The concept of business models has gained increasing interest among scholars in recent years (Spieth et al. 2014; Frankenberger et al. 2013; Foss and Saebi 2017; Hermes et al. 2019). A consensus is evolving to conceptualize business models as an overall description and architecture of how a firm creates, delivers, and captures value (Osterwalder et al. 2005; Shafer et al. 2005; Teece 2010). In this work, we build on the business model elements proposed by Wirtz et al. (2016): *value proposition*, *value creation and delivery*, and *value capture*. These elements prove to be reasonable for our research as they are used in similar ways by other taxonomies (Täuscher and Laudien 2017; Remané et al. 2017) and business model frameworks (Bocken et al. 2014; Wirtz et al. 2016).

Value proposition refers to the bundle of products and services that a firm offers, whereas value delivery relates to the identification of the target customer. Value creation describes the processes and activities, resources and capabilities, and their orchestration in the firm. Value capture explains how the firm makes money by illustrating revenue and cost structures (Frankenberger et al. 2014; Gassmann et al. 2017). Teece (2010) provided multiple examples of how business models differ based on their respective industry. While traditional firms are mainly concerned with producing physical products and optimizing supply chains, Internet-based firms operate digital services and strive to find the optimal price for information.

Blockchain

Definition and Technical Foundation

Because the development of blockchain is only in the initial stages, definitions are still emerging and no consistent definition has yet been adopted (Swan 2015). However, several authors agreed that decentralized ledger technology is key to the blockchain concept (Gomber et al. 2018; Du et al. 2019; Swan 2015). Swan (2015) described that the main idea of the blockchain is *"that the decentralized transaction ledger functionality of the blockchain could be used to register, confirm, and transfer all manner of contracts and property."*

Similarly, Gomber et al. (2018) stated that *"the central technical innovation associated with blockchain is digital ledger technology, which is defined as the use of decentralized digital trust verification through encrypted digital signatures."* Abstracting from a general definition, Christidis and Devetsikiotis (2016) proposed four key advantages of the blockchain: tolerance to node failure; single view of events; transparent, verifiable, predictable, and audible activities; and data ownership without a central authority. In general, blockchains record transactions by creating a chain of data blocks. Du et al. (2019) emphasized five IT artifacts of blockchain technology that support these transactions, which are outlined in Table 1.

Table 1 IT Artifacts of Blockchain Technology

IT artifact	Description	Reference
Distributed ledger	Distributed ledgers are databases maintained at different nodes instead of at a central location. They are identical, and each contains all the transactions.	Beck et al. (2016), Ølnes et al. (2017)
Consensus mechanism	The consensus mechanism is an algorithm that allows the secure updating of records. The ledgers can only be updated when the majority of nodes agree on the value of the data.	Notheisen et al. (2017), Tapscott and Tapscott (2016), L. Chen et al. (2018)
Encryption mechanism	The encryption mechanism consists of a public key and a private key. The public key is used to encrypt the data, and the private key is used to authenticate the participant.	Ølnes et al. (2017), Underwood (2016)
Smart contracts	Smart contracts are digitally signed, computable, self-executing agreements among participants, triggered by external events. They automatically verify and enforce the terms of the agreement.	Kshetri (2018), Gao et al. (2017)
Immutable audit trail	Participants of the ledger can access, inspect, and add to it. These historical transactions then create an audit trail. Because the ledgers cannot be modified or deleted, the audit trail is immutable.	Kshetri (2018), Underwood (2016)

Adapted from Du et al. (2019)

To provide a brief overview of the functionality of the blockchain, we rely on its first use case: transacting bitcoins. Bitcoin is a peer-to-peer electronic cash system in which transactions are executed without the orchestration of an intermediary (Nakamoto 2008). The blockchain serves as a linear register of all past transactions within the bitcoin system. Previous transactions are documented in chained blocks and new transactions are added in new blocks. The blockchain functions as a general ledger in an accounting system. However, information is not stored centrally but is kept redundantly and decentralized across all nodes within the blockchain (Franco 2014). The members of the network administer the decentralized bitcoin system by corresponding protocols and active bitcoin transactions. Every member is eligible to review the locations to which the bitcoins have been transferred while remaining anonymous as an individual entity.

Application of the Blockchain

The blockchain has the potential to transform multiple industries and to significantly alter the fields of its application. Current research is predominately investigating four domains. First, the blockchain is strongly affecting *financial services* (Underwood 2016), especially the realms of accounting, auditing, and bank transfer (Wang and Kogan 2018). By eliminating a trusted third party, firms can significantly reduce transaction costs (Nowiński and Kozma 2017). Moreover, blockchain enables cross-border transactions in a short amount of time without having to account for currency exchange fees. Those characteristics disrupt traditional business models in the financial industry (Beinke et al. 2018).

Second, blockchain research has focused on the *supply chain* as the *"most promising non-finance application of blockchain,"* which is believed *"to deliver real Return on Investment at an early stage of blockchain development"* (Reyna et al. 2018). The formal register of the blockchain enables every member of the system to identify and track the possession of a circulating item throughout the supply chain (Xu et al. 2018; Grewal et al. 2018). Incorporating such a transparent, verifiable, and shared database reduces current redundancy of every stakeholder operating and updating their database (Christidis and Devetsikiotis 2016). Another advantage of the blockchain is the ability to use connected objects installed in vehicles or storage refrigerators that track temperature to ensure that a product meets health standards along the supply chain (Pilkington 2016).

Third, blockchain can be related to the concept of *two-sided markets* (Glaser 2017). Transaction parties usually need a trusted third party that facilitates the co-creation of value in the market (Hein et al. 2019b). These include platform intermediaries, such as Google, Uber, or Amazon, to provide a safe and reliable environment for transactions (Hein et al. 2016; Hein et al. 2018). However, blockchain eliminates the need for an intermediary by using a crowd of nodes on the system (Ying et al. 2018). Such technological change drives disintermediation (Xu et al. 2017) and decentralization of transactions between members of the system (Swan 2015). Simultaneously, it eliminates centralized risk, low efficiency, and high transaction costs (Ying et al. 2018). Blockchain technology can replace platform providers with a network of nodes (Subramanian 2018). For instance, the blockchain can potentially transform the reviewing and publishing market (Janze 2017) or even make musicians' careers more sustainable (O'Dair and Beaven 2017).

Fourth, we identify a wide range of research addressing the benefits of blockchain in the domain of *social welfare* (Li et al. 2018; Jiao et al. 2018). Blockchains solutions with their decentralized approach can leverage smart contracts and enable members of the system to contract service outcomes and automate contract conclusion (Cong and He 2019). A new member can signal her genuineness and participate in market transactions without incurring information asymmetry. For voting systems, blockchain technology can digitalize it, decrease voter tampering, and possibly improve voter participation (Kshetri and Voas 2018). Furthermore, blockchain solutions offer numerous opportunities in the healthcare industry (Mettler 2016), such as sharing patient data among clinics and research institutes (Smith and Dhillon 2017). Blockchain technology can address current concerns regarding security by leveraging cryptography, decentralization, and consensus mechanisms (L. Chen et al. 2017). With an universal exchangeable format, healthcare professionals and institutions can easily access sensitive data without putting it at risk (Swan 2015). Table 2 provides an overview of the identified fields of application and their respective benefits and assets.

In conclusion, we observe that current research investigating blockchain is mainly addressing technical aspects or elaborating possible applications and advantages for suitable industries. However, linking the blockchain technology to business models remains scarce.

Blockchain technology and its implications for business models

Blockchain technology offers multiple opportunities to innovate business models. Simultaneously, it imposes certain limitations on the design of new business models. On the advantageous side, blockchains provide various incentives to convert customers to blockchain-based business models (Nowiński and Kozma 2017; Subramanian 2018; Wörner et al. 2016). Depending on its implementation, these can include significant cost reductions emerging from disintermediation (Ying et al. 2018; Xu et al. 2017), faster transaction times (Underwood 2016), reduced record-keeping for customers resulting from the distributed ledger technology, and enhanced data traceability and verification.

Table 2 Fields of Application of the Blockchain Technology

Field of Application	Incentive	Underlying Asset	Example
Financial services	Cost optimization, fraud reduction, secure transactions	Monetary asset	Direct transaction between parties
Supply chain	Data traceability, data verification, reduction of redundancy	Physical asset	Shared database for all members of the whole value chain
Two-sided markets	Disintermediation, cost optimization, risk decentralization	No asset specification	Publishing market, electricity supply
Social welfare	Authentication, security, reduction of information asymmetry	User-specific asset	E-voting, electronic health records, smart contracts

The blockchain also offers an alternative approach for *authenticating* assets, thus setting it apart from centralized transaction systems that rely on an individual organization (Nowiński and Kozma 2017). Blockchains substitute for the trust between entities, which is usually provided by central transaction systems. More specifically, blockchain technology enables small, distributed stakeholders to exercise control over transactions and to hide their identity (Subramanian 2018). A layer of encryption shields all transactions. In combination with decentralization and complex validation mechanisms, blockchains ensure security while promoting trust among members of the system (Zhu and Zhou 2016; Underwood 2016).

Besides cost reduction, traceability, and security improvements, blockchains support the business model and organizational concept of a *distributed autonomous organizations (DAO)* (Adams et al. 2017; Chohan 2017; Shermin 2017; Elsden et al. 2018; Jun and Vasarhelyi 2017). DAOs exist without central governance, are monitored by shareholders, and are coordinated through smart contracts (Diallo et al. 2018; Chohan 2017). In this way, organizations can replace intermediaries enabling them to services at a lower price.

The implications on the business model and business practices are also related to the *underlying assets* of the blockchain (Jun and Vasarhelyi 2017). Assets circulating through the blockchain can be physical, virtual, monetary, or user-specific (Smith and Dhillon 2017; Y. Chen 2018; Jun and Vasarhelyi 2017). Implementing the blockchain technology for different assets provides various opportunities for changing and improving underlying business models and firm practices with customers, competitors, and suppliers.

Finally, engaging in a blockchain-based business model enables the use of *cryptography* and *tokenization*. Cryptography can substantially change a business model's value proposition as it ensures authenticity behind all interactions in the network (Christidis and Devetsikiotis 2016). Tokenization generally refers to substituting a confidential data component by a non-confidential data component (Liu 2016; Panarello et al. 2018). The business model can enhance its value by rewarding stakeholders with tokens or by accepting third-party tokens (Subramanian 2018). Tokens in the blockchain ledger can also be utilized as certificates to verify the ownership of assets among the firm and its stakeholders (Jun and Vasarhelyi 2017). Drawbacks of blockchain technology stem from diverse requirements, such as platform openness, integration of multiple features, such as identity and privacy (L. Chen et al. 2017), and interoperability as well as performance, scale, and stability (Underwood 2016).

In sum, blockchain solutions offer various opportunities to alter existing business models and create new ones. However, research lacks empirical studies on how blockchain technology impacts business models.

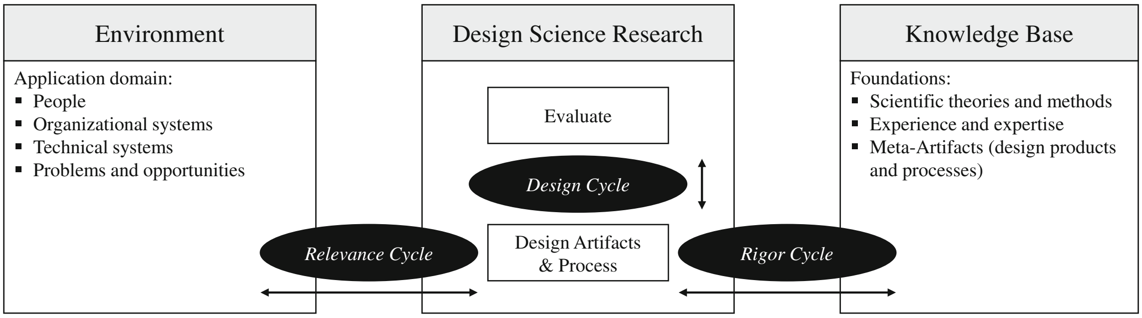

Fig. 1 Three Cycles of Design Science Research (Hevner 2007)

Research method

This paper employs design science research to develop a business model taxonomy and business model patterns for blockchain applications. By following this approach, we ensure practical relevance and scientific rigor (Hevner 2007). We iteratively build on the three cycles of design science research: the rigor cycle, relevance cycle, and design cycle (Hevner 2007). The rigor cycle incorporates the existing knowledge base and ensures that state-of-the-art research will be incorporated in the taxonomy. The relevance cycle connects design activities with real-world problems and strengthens the practical relevance of the taxonomy. The design cycle iteratively develops and evaluates the taxonomy. Figure 1 summarizes the three cycles and their relationships.

Conducting two iterations, we developed the blockchain business model taxonomy and blockchain business model patterns. Both iterations include rigor, relevance, and design cycles with a concluding evaluation. In the first iteration, we developed and evaluated the taxonomy by combining design science research with the taxonomy development method according to Nickerson et al. (2013). The second iteration builds and evaluates the archetypal business model patterns for blockchain technology. Figure 2 summarizes the iterations. In the following, we describe both iterations in more detail.

Iteration 1: Develop taxonomy

We started the first iteration with the rigor cycle and conducted a structured literature review, according to Webster and Watson (2002). We searched in the databases EBSCO, Scopus, and ScienceDirect following the search string "Blockchain*" AND ("Business Model" OR "Business Value" OR "Application" OR "Cryptography" OR "Smart Contracts"). To ensure that we include only high-quality, peer-reviewed journals, we used the VHB-JOURQAUL3 ranking.[1] To further increase topicality and completeness of our review, we included conference papers of the AIS Library matching the keyword "Blockchain." Next, we screened the abstracts and eliminated irrelevant papers and duplicates, resulting in 45 remaining articles. The full-text screening excluded an additional 15 papers. The remaining 30 documents were the basis for the forward and backward search, which yielded 17 additional papers. In sum, the literature review generated 47 relevant articles. Table 6 in the appendix shows the concept matrix of the review. The related work section builds on these results.

In the first iteration of the design cycle for the interim result, we built on the results of the literature review. The design cycle is the heart of any design science research, considering the results of the rigor and relevance cycles iteratively as input for the construction and evaluation of the underlying artifact (Hevner 2007). As the artifact is aimed to be a taxonomy, we used the taxonomy development method according to Nickerson et al. (2013) to guide the design cycle. Hence, we first defined meta-characteristics (step 1 of Nickerson et al. (2013)). We chose the business model elements *value proposition, value creation and delivery,* and *value capture* as commonly used in other business model taxonomies (Täuscher and Laudien 2018; Remané et al. 2017) and in business model frameworks (Bocken et al. 2014; Wirtz et al. 2016). Second, we defined ending conditions for the iterative method (step 2 of Nickerson et al. (2013)), where we followed the conditions according to the authors. After setting the foundations of taxonomy development, we conducted the first design cycle.

From the literature review, we followed a conceptual-to-empirical approach (Nickerson et al. 2013) to derive the dimensions and characteristics of the blockchain business model taxonomy. For business model dimensions, we refined the meta-characteristics from above with the dimensions *service provision, key channel, key resources, key partner, target segment, revenue stream,* and *cost structure* (Wirtz et al. 2016). For blockchain-specific aspects, we included four additional dimensions based on the literature review: *Incentives* (Nowiński and Kozma 2017; Subramanian 2018; Wörner et al. 2016), *Underlying Asset* (Smith and Dhillon 2017; Y. Chen 2018; Jun and Vasarhelyi 2017), *DAO Affiliation* (Chohan 2017; Adams et al. 2017; Shermin 2017; Elsden et al. 2018; Jun and Vasarhelyi 2017), and *Token System* (Panarello et al. 2018). This led to an initial, conceptual taxonomy.

[1] http://vhbonline.org/vhb4you/jourqual/vhb-jourqual-3

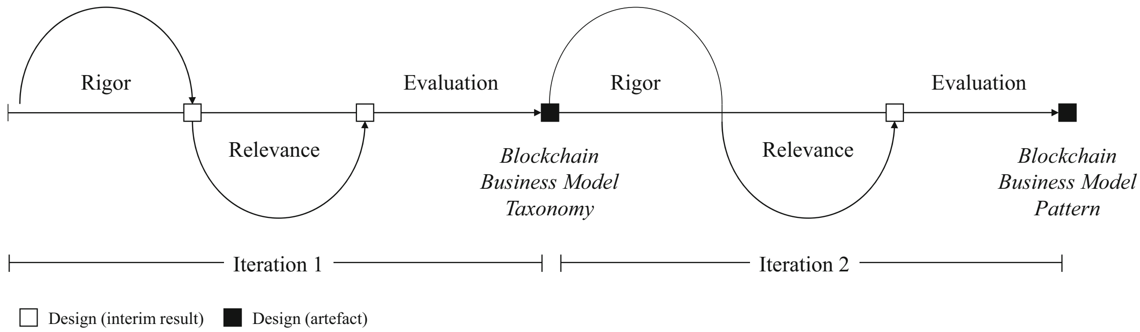

Fig. 2 Three Cycles of Design Science Research

For the relevance cycle, we compiled a database of firms that use blockchain technology as an integral part of their business model. We used CrunchBase as the world's largest database for new ventures (Marra et al. 2015). Because blockchain is a novel technology, the focus on new ventures enables us to analyze a breeding ground of emerging business models. We included all firms in the CrunchBase category "Blockchain" as of January 2018. We discovered 1237 firms as a possible sample. To ensure that our sample only contains successful and relevant firms, we used the following four criteria. First, we included only startups that already received funding to ensure data quality and potential success of firms (Krishna et al. 2016). Second, we excluded firms that went bankrupt or did not have an English homepage. Third, we analyzed the business model of the firms and included only firms that use blockchain technology as an integral part of their business models. For example, we excluded firms such as wallet providers or cryptocurrency exchange markets because they do not directly use the technology. Fourth, we analyzed the required information about the firms and excluded ones that did not provide sufficient information about their business model. After considering all factors, the final set of relevant blockchain firms covered 99 cases.

In the next design cycle, we continued the iterative taxonomy development with an empirical-to-conceptual approach (step 3 according to Nickerson et al. (2013)) building on the results of the previous rigor and relevance cycles. Using case survey guidelines (Larsson 1993) and taxonomy development steps (Nickerson et al. 2013), we classified all firms of our sample (step 4e) with the current taxonomy, identified new characteristics (step 5e), grouped these characteristics into dimensions, and revised the taxonomy (step 6e). In this coding process, we included the firms' webpages, existing technical or white papers, and information from CrunchBase to ensure data triangulation. This procedure led to the following new dimensions *intermediation form, user diversification, customizability, value chain position, consensus mechanism, additional technology*, and *currency acceptance*. We distinguished three dimensions, *blockchain sourcing, blockchain type*, and *underlying blockchain* as *key resources* and separated *target segment* into *user* and *customer.*

In the last step of the first iteration, we evaluated the taxonomy according to the ending conditions (step 7) of Nickerson et al. (2013). We were able to distinctly classify all firms of our sample without changing dimensions or characteristics. All objective and subjective ending conditions were fulfilled (Nickerson et al. 2013). To ensure statistical independence among dimensions, we analyzed their correlations. No dimension could be explained with another dimension or combinations of others. Hence, every dimension is important for explaining blockchain business models. Accordingly, we can show that taxonomy provides value, validity, and applicability (Hevner 2007).

Iteration 2: Develop patterns

In the second iteration, we derived the blockchain business model patterns. Again, we started with a rigor cycle incorporating the results of the literature review. The rigor cycle resulted in an initial set of patterns focused on application areas, such as *financial services* (Underwood 2016), *supply chain* (Reyna et al. 2018), *two-sided markets* (Glaser 2017), and *social welfare* (Li et al. 2018; Jiao et al. 2018).

In the subsequent relevance and design cycles, we performed a cluster analysis (Punj and Stewart 1983) on the sample of 99 firms and the underlying business model taxonomy to refine the initial business model patterns. We transformed the dataset of 99 firms and 22 dimensions of the taxonomy to dichotomous dummy variables for each characteristic of each dimension to measure distances. This process resulted in a vector with 84 binary entries for each firm. We performed hierarchical, agglomerative clustering using the Ward method (Kaufman and Rousseeuw 2009; Struyf et al. 1997). We used several approaches to determine the appropriate number of clusters, as the a priori definition of the number of clusters is a well-known issue in cluster analyses (Anderberg 2014). First, we used the point biserial correlation (Milligan and Cooper 1985) and the C-index (Hubert and Levin 1976), which both indicate five clusters as the best solution. Second, we qualitatively analyzed the five clusters to ensure that clusters are separable (inter-heterogeneity) and that single clusters share common characteristics (intra-homogeneity).

Both are true for the chosen number of five clusters, indicating that the number of clusters is valid and useful.

For evaluation, we performed Fisher's exact test (Fisher and Bennett 1990) to confirm that the five patterns significantly differ in each dimension. We tested if the five clusters significantly vary in each of the 22 dimensions of the taxonomy. All five clusters differ in almost every dimension with a *p* value lower than 5%. Two dimensions show a p value lower than 10%. Table 7 in the appendix shows the exact *p* values. Moreover, we already qualitatively evaluated the patterns by confirming the number of clusters. The results indicate that the number of clusters and the clusters themselves are valid and applicable.

Results

Business model taxonomy

The resulting taxonomy contains 22 dimensions, each with two to five distinct characteristics. The taxonomy is visualized as a morphological box wherein a specific combination of characteristics describes the business model of a firm. The taxonomy contains dimensions in which the business models differ. Any further dimension would unnecessarily extend the taxonomy without providing additional information. Table 3 shows the complete taxonomy and Tables 8, 9, 10, and 11 in the appendix define each dimension and related characteristics.

Business Model Patterns

Five archetypal patterns emerged as salient and similar configurations of the business model taxonomy. The five patterns cover every business model of the sample firms, ranging from 10 firms in pattern 3 to 37 firms in pattern 2. Each pattern has different centers along the dimensions and characteristics in the blockchain business model taxonomy, demonstrating intra-homogeneity and inter-heterogeneity. Table 4 shows all five business model patterns and their definitions.

Table 5 provides an overview of the specific characteristics of each business model pattern. The table shows the differentiating characteristics of each pattern. These characteristics are based on a relative value of the frequency of a particular characteristic within one pattern to the overall frequency. In this manner, we can indicate characteristics that make a pattern unique and different from others. Consequently, not all firms of one pattern have precisely the same combination of characteristics. One pattern can cover more than one characteristic in some dimensions. In the following, we explain every pattern in detail by focusing on the most differentiating dimensions and characteristics for each pattern.

Pattern 1: Blockchain for Business Integration

The first pattern represents business models that provide the integration of blockchain solutions into existing value networks. Providers sell, for example, blockchain solutions for improving the data interoperability of firms in a supply chain from the Internet of things (IoT) devices. Providers increase data transparency for every participant in the blockchain ecosystem. Contractual time-stamped handshakes of IoT devices enable tracing and verifying data for all parties and, hence, prevent cyber-physical attacks. Customers and users are legal persons. The underlying asset of the blockchain is typically physical. The provider offers a system where IoT devices can generate data and communicate with the blockchain. Providers usually do not offer one standardized product but adjust it to the individual business needs of their customers. Participants store all relevant asset information in the blockchain. Hence, every member can continuously track the current state of the physical assets. Such distributed databases enable smart contracts and can provide additional business value for customers. The challenge is to integrate every member's system, typically ERP systems, in the blockchain solution to leverage its full potential.

Contrary to other patterns, providers offer individual blockchain solutions to customers with a specific business need instead of using the blockchain themselves. Hence, their value chain position is blockchain mediator. They typically use several underlying blockchain technologies and modified consensus mechanisms for a consortium of users. For revenue streams, operators typically do not provide a currency or token in the blockchain but charge their customers with periodic fees.

Modum[2] is a typical example of this pattern. They offer services for supply chain monitoring using IoT sensor devices to generate data (Modum 2018). They store data in a distributed database, granting access to every member on their blockchain. A characteristic of this pattern is that Modum provides its services for different industries, including pharmaceuticals and the supply chain in general.

Pattern 2: Blockchain as Multi-Sided Platform

The second pattern comprises providers that use blockchain solutions as a medium to operate a platform or multi-sided market. Customers and users are typically end users. Platform providers integrate firms to offer complementary products or services. Hence, they rely on industry partners as key partners. Some providers additionally enable users to offer or sell new assets using the blockchain and enable their customers to become complementors. The underlying asset is typically a virtual or a user-specific asset. The former primarily covers enhancing online-gaming experiences (e.g., DMarket[3]), whereas the latter

[2] https://modum.io/
[3] https://dmarket.com/

Table 3 Blockchain Business Model Taxonomy

Layer	Dimension	Sub-dimension					
Value Proposition	Value Classification	*Service Provision*	Marketplace Offering	Interoperability	Transfer of Value	Authentication	API BC
		Incentive	Intermediation Improvement	Cost Optimization	Data Traceability and Verification	Security Enhancement	Blockchain Offering
	Customer Target	*Customer*	Natural Person	Legal Person	Both		
		User	Natural Person	Legal Person	Both		
		Intermediation Form	Intergroup	Intragroup	Inside Group	Inter- & Intragroup	No Intermediation
		User Diversification	User Positioning	No Diversification			
	Underlying Asset		Physical Asset	Virtual Asset	User Specific Asset	Money	No Asset Specification
Value Creation & Delivery	Key Partner		Technology Partner	Industry Partner	Technology and Industry Partner	Stand Alone	
	Key Channel		Mobile Application	Website	ERP Integration	Technology Provision without Channel	
	Customizability		External Developer Integration	Internal Developer Integration	None	Both	
	DAO-Affiliation		DAO	DAO-Enabler	DAO-Supporter	No DAO-Alignment	
	Blockchain Classification	*Value Chain Position*	Blockchain Provider	Blockchain Enabler	Blockchain Mediator	Blockchain User	
		Blockchain Sourcing	External Blockchain Use	Own Blockchain	Blockchain Combination	Existing Blockchain modified	
		Blockchain Type	Public	Private	Consortium		
		Underlying Blockchain	Bitcoin	Ethereum	Other	Several	
		Consensus Mechanism	Self-Created	Modified	Existing		
	Additional Technology		IoT	Dapps	Cloud	Big Data Analytics	None
Value Capture	Revenue Stream	*Customer Charge*	Free	Regularly Fee	Cost per Transaction		
		Currency Acceptance	Solely Own Token	Additional Cryptocurrency	Additional Fiat-Currency	Additional Fiat- and Cryptocurrency	No Currency in BC
		Token System	No Token	No Token Listing	Own Token Listing	Dual Token System	
	Cost Structure	*Provision Cost*	Platform Provision	SDK Provision	Software Provision		
		Network Sourcing	External Blockchain Use	Own Mining Network			

mainly targets the distribution and selling of data (e.g., BitClave[4]) or labor (e.g., Bitjob[5]). Complementors offer their services through websites and do not offer customization. Providers typically use the blockchain framework Ethereum and existing consensus mechanisms because their business does not require specific blockchain modifications.

Contrary to other patterns, the operators typically renounce relying on additional technology. Customers are mainly charged with transactional fees for propagating transactions into the blockchain. Some providers even offer two different tokens in their blockchain, for example for separating currency and assets (e.g., Decentraland[6]).

[4] https://www.bitclave.com/
[5] https://bitjob.io/

[6] https://www.decentraland.org/

Table 4 Blockchain Business Model Patterns

Pattern (P)	Definition	Number of firms
P1: Blockchain for Business Integration	Provision of a standardized shared database to improve interoperability among users	14
P2: Blockchain as Multi-Sided Platform	Provision of a marketplace without regulating intermediaries	44
P3: Blockchain for Security	Reinforcement of security aspects by using several aspects of the blockchain technology	7
P4: Blockchain Technology as Offering	Provision of blockchain-APIs	21
P5: Blockchain for Monetary Value Transfer	Enablement of direct value transfer among peers	13

An additional example is Storm,[7] which provides a marketplace where different consumers can provide and fulfill microtasks. Storm earns rewards in the form of cryptocurrency. Similarly, Power Ledger[8] offers its complementors the ability to sell self-generated electricity, thereby replacing traditional energy suppliers. A more disruptive example is Rega,[9] which offers peer-to-peer insurance ("Crowdsurance"). It enables users to join forces in different insurance platforms, protect each other, and reduce costs by eliminating insurance firms as intermediaries.

Pattern 3: Blockchain for Security

The third pattern builds on cryptography and solutions that provide ownership clarification using cryptography. The solution can be applied to non-physical goods such as data or intellectual property. The asymmetric cryptography allows only the corresponding owner to alter either the data or its ownership. The distributed blockchain informs every participant regarding an ownership change.

Various firms address those features of blockchain technology to provide security of distributed data. The combination of trusted hardware and blockchain technology enable users to authenticate themselves securely. Providers offer these services to legal persons (customers) but target the needs of natural persons (users). The underlying assets are typically users' data. Providers often join forces with technology partners to offer security features. Those services often include additional technologies, such as cloud. Providers sell these without a specific channel. Most of our sample firms do not offer customizable solutions. However, they let firms use their solutions for various application areas. The value chain position is blockchain enabler. Many firms of these patterns use an existing, modified blockchain, typically Bitcoin for a private network with own consensus mechanism. Providers generate revenues with transaction fees and by generating their tokens.

An example is Bluezelle,[10] who provide decentralized storage. They build on the enhancement of privacy, reliability, and immutability of blockchain solutions in addition to reduced costs compared with single system databases. Similarly, NuCypher[11] provides a privacy infrastructure for the decentralized web. Rivetz[12] offers security features for existing assets that slowly become digital.

Pattern 4: Blockchain Technology as Offering

The fourth pattern offers blockchain-APIs to developers. Providers offer a blockchain infrastructure without any further specification of assets. Most customers are legal persons, whereas users also include natural persons. Compared with other patterns, they do not specify the underlying asset or provide a specific channel as they often distribute their API as an open-source. This isolated business model does not intermediate existing value chains and does not rely on strong partnerships. To separate from existing blockchains, providers develop their blockchain solution with modifications, such as modifying the underlying consensus mechanism. These modifications target more specific business needs. Therefore, we attribute those business models as DAO enabler with the value chain position blockchain enabler because they offer various implementations independent of the application area. Although they do not charge their customers, providers profit from the distribution of their tokens; they typically keep a portion of their tokens. A subsequent increase in demand leads to a higher value of those tokens and generates indirect income. Typically, they additionally accept other cryptocurrencies.

Examples include Qtum[13] and Tezos.[14] Both offer blockchain infrastructure to build decentralized apps, including the possibility of smart contracts and the implementation of the proof-of-

[7] https://www.stormx.io/
[8] https://www.powerledger.io/
[9] https://rega.life/

[10] https://bluzelle.com/
[11] https://nucypher.com/
[12] https://rivetz.com/
[13] https://qtum.org/
[14] https://tezos.com/

Table 5 Characteristics of Business Model Patterns

Pattern			**Blockchain for Business Integration**	**Blockchain as Multi-Sided Platform**	**Blockchain for Security**	**Blockchain Technology as Offering**	**Blockchain for Monetary Value Transfer**
Value Proposition	Value Classification	*Service Provision*	Interoperability	Marketplace Offering	Authentication	API – Blockchain	Transfer of Value
		Incentives	Data Traceability and Verification	Mediation Improvement	Security Enhancement	Blockchain Offering	Cost Optimization
	Customer Target	*Customer*	Legal Person	Natural Person	Legal Person	Legal Person	Both
		User	Legal Person	Natural Person	Natural Person	Both	Both
		Intermediation Form	Inter & Intra	Inter & Intra	Intergroup	No Intermediation	Intragroup
		User Diversification	No Diversification	User positioning	User positioning	No Diversification	No Diversification
	Underlying Asset		Physical Asset	Virtual Asset	User-specific Asset	No Asset Specification	Money
Value Creation and Delivery	Key Partner		Stand-Alone	Industry Partner	Technology Partner	Stand-Alone	Stand-Alone
	Key Channel		ERP Integration	Website	Technology Provision without Channel	Technology Provision without Channel	Mobile Application
	Customizability		Internal Developer Integration	None	None	Both	None
	DAO Affiliation		No DAO Alignment	No DAO Alignment	No DAO Alignment	DAO Enabler	No DAO Alignment
	Blockchain Classification	*Value Chain Position*	Blockchain Mediator	Blockchain User	Blockchain Enabler	Blockchain Enabler	Blockchain User
		Blockchain Sourcing	Blockchain Combination	External Blockchain Use	Existing Blockchain modified	Own Blockchain	Own Blockchain
		Blockchain Type	Consortium	Private	Private	Public	Private
		Underlying Blockchain	Several	Ethereum	Bitcoin	Others	Others
		Consensus Mechanism	Modified	Existing	Self-Created	Self-Created	Self-Created
	Additional Technology		IoT	None	Cloud	Dapps	None
Value Capture	Revenue Stream	*Customer Charge*	Regularly Fee	Cost per Transaction	Cost per Transaction	Free	Cost per Transaction
		Currency Acceptance	No Currency in BC	Solely own Token	Solely own Token	Additional other Cryptocurrency	Solely own Token
		Token System	No Token	Dual Token System	Own Token Listing	No Token	Own Token Listing
	Cost Structure	*Provision Cost*	SDK Provision	Platform Provision	SDK Provision	SDK Provision	Platform Provision
		Network Sourcing	External Blockchain Use	External Blockchain Use	Own Mining Network	Own Mining Network	Own Mining Network

stake-algorithm. 0xproject[15] created a blockchain for the decentralized exchange of assets. They focus on the tokenization and exchange aspect of blockchain technology.

Pattern 5: Blockchain for Monetary Value Transfer

The fifth pattern covers firms related to cryptocurrencies. Bitcoin, the first publicly introduced blockchain, developed an electronic cash system, which can replace intermediaries such as financial institutions and saves expenses. Currently, many firms discovered the various advantages of cryptocurrency and implemented their platforms for value transfer. These firms typically follow the *Blockchain for Monetary Value Transfer* business model pattern.

Providers target both legal and natural persons as their customers and users. The intermediation typically occurs within groups (intragroup), enabling the seamless transaction between different peers. Providers focus on money as the underlying asset. They do not heavily rely on partners and offer their services based on mobile applications without customizability as they aim for convenient and cheap transactions. Their value chain position is blockchain user. Providers typically use an external blockchain infrastructure and its underlying consensus mechanism. They do not introduce additional technology. Providers generate revenue by charging fees for every transaction propagated into the network. Furthermore, they distribute their tokens. To increase the value of their tokens, they allow for the transfer of only their tokens within their offerings.

An example is MakerDao,[16] which aims to mitigate the lack of price-stability of cryptocurrencies. They minimize volatility by linking their tokens to an existing asset, such as fiat currency. ETHLend[17] shifts their attention to the loan-aspect of currency. They reduce costs for creditor and debtor by removing cross-border transaction costs.

Discussion

The blockchain is a contemporary technology that has the potential to build the foundation for new business models (Iansiti and Lakhani 2017). However, there is a vast gap between the promised business value and actual value. In addition, it remains unclear how blockchain technology can influence the emergence of new business models.

To investigate the business value of blockchain, we follow a design science research approach (Hevner 2007) and develop a taxonomy of blockchain business models. The taxonomy is based on blockchain and business model literature, and 99 firms that use blockchain as a fundamental technology of their business model. Building on the taxonomy, we conducted a cluster analysis of the 99 firms to derive five archetypal business model patterns that illustrate how blockchain changes existing and triggers new business models.

The first pattern is *Blockchain for Business Integration*, which illustrates how companies provide a standardized shared database that improves interoperability among actors of a value chain. Second, *Blockchain as Multi-Sided Platform,* uses direct peer-to-peer transactions to overcome restrictions on what can be offered by whom, hence, enabling new business models (Hein et al. 2019a). Those peer-to-peer transactions replace the need for centralized intermediaries (Hein et al. 2019c). Third, *Blockchain for Security* uses cryptography for security improvements and enables services that previously required physical authentication. Fourth, *Blockchain Technology as Offering* provide the technical infrastructure to enable blockchain-based business models. Fifth, *Blockchain for Monetary Value Transfer* uses cryptocurrencies and reduces transaction costs by eliminating the need for a trusted third party. The five patterns reveal that some, blockchain-based firms provide a new value proposition, while others constitute entirely new business models.

Contribution to theory

These findings contribute to the blockchain technology literature and the business model literature, including business model innovation.

Contribution to business model literature

The findings contribute in two ways to the business model literature. First, current literature acknowledges the potential of blockchain to change existing models and trigger entirely new business models in various industries (Iansiti and Lakhani 2017; Lacity 2018; Kshetri 2018; Wang and Kogan 2018) without empirically addressing how this change occurs. This study empirically investigates this phenomenon. The taxonomy enhances the understanding of how blockchain impacts business models. It can serve as a vocabulary that fosters a systematic description of blockchain business models. The taxonomy further illustrates opportunities for business model innovations without oversimplifying their complexity.

Moreover, the five archetypal business model patterns structure the impact of blockchain on business models and further support an understanding of it. The patterns demonstrate possible options for innovating a business model to utilize blockchain technology. We follow the call for analyzing business model patterns in a changing field (Remané et al. 2017). Further, we investigate the understudied topic of how new technologies, i.e., blockchain technology, influence traditional business models (Johnson et al. 2008; Bock and Wiener 2017). Hence, with a business model taxonomy and five archetypal

[15] https://0x.org/
[16] https://makerdao.com/
[17] https://ethlend.io/

business model patterns, we establish an understanding of how blockchain technology can impact existing and new business models.

Second, our research method illustrates how to derive a technology-specific business model taxonomy and business model patterns utilizing design science, taxonomy development, case survey, and cluster analysis. Design science serves as an overall research strategy with rigor, relevance, and design cycles (Hevner 2007). Guidelines of case surveys, taxonomy development, and cluster analysis further define these cycles. Case surveys provide the empirical base with a generalizable, cross-sectional analysis (Larsson 1993). Taxonomy development then adds a systematic approach to integrate empirical and conceptual research (Nickerson et al. 2013). Cluster analysis finally ensures rigor in designing patterns (Kaufman and Rousseeuw 2009; Struyf et al. 1997). We build on all three levels of business models: real-world instances (cases), business model elements (taxonomy), and patterns (Osterwalder et al. 2005). Therefore, we leverage the full potential of the business model concept. Building on these methods, we show how to systematically derive a specific business model taxonomy and patterns that incorporate the existing knowledge base while ensuring practical relevance.

In sum, we first offer a shared language for describing, classifying, visualizing, and analyzing blockchain business models as a basis for future research. Second, our widely applicable research approach shows how to develop a business model taxonomy and how to identify business model patterns for a particular field of application. Hence, we contribute to the business model literature and the growing field of enterprise classifications based on business models (Täuscher and Laudien 2018).

Contribution to Blockchain literature

Literature about blockchain technology predominantly focuses on technological aspects (Nakamoto 2008; Wang and Kogan 2018; Eyal and Sirer 2018) and neglects its business value. Further, current research lacks empirical studies on how blockchain technology changes business models. This study extends blockchain literature by incorporating contemporary research on blockchain technology and its applications with recent developments from practice. By empirically and conceptually developing a blockchain business model taxonomy and extracting five archetypal patterns for blockchain business models, we enhance the understanding of how blockchain technology impacts business models and business value. The taxonomy indicates critical dimensions describing and analyzing businesses operating the blockchain technology. These dimensions include both technical aspects of blockchain solutions as well as elements of business models. The patterns further show tangible instances of how to leverage blockchain technology for business. By investigating blockchain business models, this paper opens up a business perspective on the technology-driven body of literature on blockchain technology.

Implications for practice

For practice, we provide a market overview enhancing the understanding of important aspects of blockchain business models by aggregating from many single entities to archetypal business model patterns. The taxonomy further can serve as a tool for business model innovation (Remané et al. 2016; Weking et al. 2018b). Practitioners can use the taxonomy and patterns to assess opportunities and barriers to integrating blockchain technology in their current business model. The characteristics of the taxonomy and the case examples may inspire practitioners to innovate their business model and allow managers to discover business model innovation opportunities. The five patterns guide the transformation process by specifying the relevant dimensions for a business model innovation. Firms can use patterns and related cases in an ideation phase to identify options for business model innovation toward blockchain and assess their implementation in the firm's context. The taxonomy and its business model patterns can be used as decision support for the evaluation and implementation of business ideas, such as building on an own blockchain solution or external blockchain solution, knowing ways to tokenize assets, or knowing ways to generate revenues.

Moreover, managers can build on the patterns to analyze their current market and identify opportunities and possible market entries for blockchain firms. The results can indicate white spots in the value network as entry points for blockchain provides and support decision making on whether and how to implement blockchain technology. Hence, the business model taxonomy, patterns, and related cases serve as technology-specific support for business model innovation.

Limitations and future research

This paper is subject to three main limitations. First, Nickerson et al. (2013) stated that taxonomies are never perfect and exhaustive. However, the taxonomy and patterns serve as the current state of blockchain business models. As the blockchain application field is evolving rapidly, further research can extend both results with future business models.

Second, we build on the CrunchBase database, the world's largest startup database (Marra et al. 2015). Consequently, we focus on rather new ventures and cannot ensure that all firms that use blockchain technology are part of our sample. For example, we did not find the blockchain platform hyperledger in our cases, since its target group is rather large and incumbent firms. Hyperledger typically comes with licensing costs, whereas startups look for open blockchain solutions. However, the focus on new ventures allows us to better capture the new and still emerging field of blockchain applications. Furthermore, CrunchBase ensures proper data quality, and several other studies have already used it (Block and Sandner 2009; Marra et al. 2015; Werth and Boeert 2013; Yu and Perotti 2015). For data triangulation in the coding process, we consider the firms' webpages, existing technical or white papers, and CrunchBase information. This approach strengthens the validity of our dataset.

Third, we could not evaluate the archetypal business model patterns regarding business performance (cf. Weking et al. 2019). However, while blockchain applications are at an early stage to assess their success, the archetypal patterns indicate a fruitful avenue for blockchain business models and applications.

As blockchain technology is still emerging, and there is a gap between promised and actual business value, this research allows for future research of several aspects. The business potential of blockchain technology is still in its infancy and will evolve further. Future research can build on our taxonomy and archetypal business model patterns as constructs for further empirical studies, qualitative or quantitative. The taxonomy and its patterns serve as an extendable basis for further research providing the main dimensions and corresponding business model patterns. With this business model taxonomy, we want to encourage researchers to study and hypothesize about the relationships among concepts, as proposed by Glass and Vessey (1995). With increased progress of leveraged business value of blockchain technology in practice, research can extend the taxonomy and patterns toward a maturity model for blockchain business models. Moreover, researchers can build on the method integrating case surveys (Larsson 1993), taxonomy development (Nickerson et al. 2013), cluster analysis (Kaufman and Rousseeuw 2009; Struyf et al. 1997), and design science research (Hevner 2007) to develop business model taxonomies and patterns for various fields of application.

Conclusion

Current research emphasizes the technological advantages and the possible application fields of the blockchain technology (Kshetri 2018; Wang and Kogan 2018). Studies have stressed the ability of blockchain solutions to alter and disrupt existing business models and create entirely new business models (Iansiti and Lakhani 2017). However, current research about blockchain solutions focuses on only technological aspects (Nakamoto 2008; Wang and Kogan 2018; Eyal and Sirer 2018) and its application in practice (Kshetri 2018; Jun and Vasarhelyi 2017; Radanović and Likić 2018). Research does not explain a possible influence of blockchain technology on business models and lacks empirical investigations. Consequently, in practice, there is still a gap between possible business value and actual business value delivered.

Therefore, we develop a taxonomy of blockchain business models based on the literature and 99 firms building on blockchain technology. In addition, we identify five archetypal patterns of business models levering blockchain technology, namely *Blockchain for Business Integration*, *Blockchain as Multi-Sided Platform, Blockchain for Security, Blockchain Technology as Offering,* and *Blockchain for Monetary Value Transfer.* We build on design science research (Gregor and Hevner 2013) as a research strategy to guide the research methods case survey (Larsson 1993), taxonomy development (Nickerson et al. 2013), and cluster analysis (Kaufman and Rousseeuw 2009; Struyf et al. 1997).

This paper contributes to business model research by fostering an understanding of how technology, i.e., blockchain technology, influences existing and new business models. The blockchain business model taxonomy is a framework for describing, classifying, visualizing, and analyzing technology-specific business models, whereas the archetypal patterns show typical instances of it. We also provide a research method to develop field-specific business model taxonomies and patterns by combining the three cycles of design science with case surveys, taxonomy development, and cluster analysis. The results contribute to blockchain literature by introducing the business model concept and combining business and technical aspects for blockchain business models. Findings show how blockchain technology can create business value and enrich the technology-driven blockchain literature. For practice, the taxonomy and patterns identify opportunities for leveraging blockchain technology and help understand important aspects of blockchain business models. Future research can build on our extendable taxonomy and archetypal patterns as constructs for further studies to shed more light on the still rapidly evolving topic of blockchain technology and its business models.

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Appendix

Literature Review

Table 6 Concept Matrix of the Literature Review

Reference	Cryptography	Consensus Mechanism	Token	Smart Contracts	DAO	Finance	Citizen Welfare	Marketplace	Supply Chain
Wang and Kogan (2018)	X					X			
Y. Chen (2018)			X	X	X				
Jun and Vasarhelyi (2017)	X	X				X			
Lacity (2018)								X	X
Radanović and Likić (2018)							X		
Gomber et al. (2018)						X			
Kshetri and Voas (2018)							X	X	
Gökalp et al. (2018)							X		
Norta (2015)				X	X				
Lin et al. (2018)		X							
Adams et al. (2017)						X	X		
Shermin (2017)			X	X	X		X		
Subramanian (2018)								X	
Kshetri (2018)									X
Ying et al. (2018)								X	
Carlozo (2017)	X	X							
Grewal et al. (2018)									X
Woodside et al. (2017)	X	X							
Brammertz and Mendelowitz (2018)						X			
Kim and Laskowski (2018)									X
Kokina et al. (2017)	X	X				X			X
Kshetri (2017)	X						X		X
Kavassalis et al. (2018)						X			
Beinke et al. (2018)						X			
Smith and Dhillon (2017)							X		
Oliveira et al. (2018)			X						
Hans et al. (2017)				X					
Elsden et al. (2018)			X			X	X		
Mashatan and Roberts (2017)						X			
Janze (2017)								X	
Nowiński and Kozma (2017)						X			X
Christidis and Devetsikiotis (2016)	X	X	X	X					
Nakamoto (2008)	X	X	X						
Dai et al. (2018)	X	X	X						
Szabo (1997)				X					
O'Dair and Beaven (2017)								X	
Swan (2015)	X	X		X		X	X	X	
Diedrich (2016)			X	X	X				
Reyna et al. (2018)						X	X	X	X
Mendling et al. (2018)	X			X					
García-Bañuelos et al. (2017)	X								
Mashatan and Roberts (2017)	X	X							
Zhao et al. (2016)	X	X							X
Fernández-Caramés and Fraga-Lamas (2018)	X	X		X		X	X	X	X
Panarello et al. (2018)	X	X	X	X					
Treiblmaier (2018)	X	X		X					X
Eljazzar et al. (2018)	X	X							X

Cluster Analysis

Table 7 Fisher's Exact Test of Clusters

Dimension	p value
1	2,20 E-16 ***
2	2,20 E-16 ***
3	2,20 E-16 ***
4	6,62 E-07 ***
5	2,20 E-16 ***
6	6,67 E-04 ***
7	2,20 E-16 ***
8	1,88 E-10 ***
9	7,30 E-16 ***
10	3,86 E-08 ***
11	1,95 E-06 ***
12	2,20 E-16 ***
13	5,07 E-04 ***
14	5,79 E-12 ***
15	5,05 E-04 ***
16	8,52 E-02 $^{+}$
17	9,73 E-02 $^{+}$
18	2,23 E-06 ***
19	4,33 E-04 ***
20	1,40 E-02 *
21	2,20 E-16 ***
22	1,46 E-03 **

$^{+}$ *p* < 0.1; **p* < 0.05; ***p* < 0.01; ****p* < 0.001

Blockchain Business Model Taxonomy

Table 8 Definitions of Blockchain Business Model Taxonomy Dimensions

Value Proposition	Value Classi-fic-ation	*Service Provision*	Which service does the operator provide?
		Incentive	How does the operator incentives customers to use its offering?
	Customer Target	*Customer*	To whom does the operator sell its value proposition?
		User	Who uses the operator's business model?
		Intermediation Form	What kind of mediation does the business model incorporate?
		User Diversifica-tion	Does the operator diversify its customer?
	Underlying Asset		What kind of underlying asset runs through the blockchain?
Value Creation & Delivery	Key Partner		Key partnership of operator
	Key Channel		Key channel of operator
	Customizability		Does the operator allow for customizability of its offering?
	DAO-Affiliation		How is the business model affiliated to DAOs?
	Blockchain Classificat-ion	*Value Chain Position*	What position does the operator take within the blockchain value chain?
		Blockchain Sourcing	Sourcing of underlying blockchain
		Blockchain Type	Type of underlying blockchain
		Underlying Blockchain	Root of underlying blockchain
		Consensus Mechanism	Type of underlying consensus mechanism
	Additional Technology		Non-blockchain related technologies, where the Business Model builds on.
Value Capture	Revenue Stream	*Customer Charge*	Revenue generation
		Currency Acceptance	Which currencies does the operator allow within its offering?
		Token System	How does the operator distribute its token?
	Cost Structure	*Provision Cost*	What provision costs do occur?
		Network Sourcing	Root of blockchain network

Table 9 Definition of Characteristics: Value Proposition

Value Proposition	Value Classification	*Service Provision*	Marketplace Offering	Offering of marketplace without intermediary.
			Interoperability	Alignment of separated databases.
			Transfer of Value	Offering of environment to complete transactions.
			Authentication	Enhancement of authentication through advanced personalized data security.
			API - Blockchain	Offering of blockchain as open-source code.
		Incentive	Intermediation Improvement	Business model improves intermediation for customer.
			Cost Optimization	Business model offers cost optimization for customer.
			Security Enhancement	Business model increases customers' data security.
			Data Traceability and Verification	Business model increases data transparency and traceability for customers.
			Blockchain Offering	Business model offers blockchain infrastructure.
	Customer Target	*Customer*	Natural Person	Customers are individual human beings.
			Legal Person	Customers are private or public organizations.
			Both	Customers are human beings and organizations.
		User	Natural Person	Users are individual human beings.
			Legal Person	Users are private or public organizations.
			Both	Users are human beings and organizations.
		Intermediation Form	Intergroup	Business model intermediates vertically along value chain.
			Intragroup	Business model intermediates horizontally along value chain.
			Inside-Group	Business model intermediates within one group of value chain.
			Inter & Intra	Business model intermediates horizontally and vertically along value chain.
			No Intermediation	Business model provides no intermediation.
		User Diversification	User positioning	Business model classifies existing user into groups.
			No Diversification	Business model does not classify its users.
	Underlying Asset		*Physical Asset*	Underlying asset is physical.
			Virtual Asset	Underlying asset is virtual.
			User specific Asset	Underlying asset is user-personalized (IP, Labor, Data, …).
			Money	Underlying asset represents equivalent of money.
			No Asset Specification	Underlying asset is not specified.

Table 10 Definition of Characteristics: Value Creation & Delivery

Value Creation & Delivery	Key Partner		*Technology Partner*	Business model includes technological partner.
			Industry Partner	Business model includes industrial partner.
			Technology and Industry Partner	Business model includes technological and industrial partner.
			Stand-Alone	Business model exists without partner.
	Key Channel		*Mobile Application*	Distribution of offerings through mobile application (and potentially website).
			Website	Distribution of offerings through website.
			ERP Integration	Integration of business model into existing ERP systems.
			Technology Provision without Channel	Provision of business model without channel specification.
	Customizability		*External Developer Integration*	Non-customer development necessary for integration of blockchain.
			Internal Developer Integration	Customer development necessary for integration of blockchain.
			None	No development for integration of blockchain necessary.
			Both	Customer and Non-Customer development necessary for integration of blockchain.
	DAO-Affiliation		*DAO*	Business model functions as DAO.
			DAO Enabler	Business model enables the emergence of DAO.
			DAO Supporter	Business model supports the integration of DAO.
			No DAO Alignment	Business model has no DAO Alignment.
	Blockchain Classification	*Value Chain Position*	Blockchain Provider	Provider offers blockchain infrastructure.
			Blockchain Enabler	Provider facilitates the integration of an existing blockchain for a range of business models.
			Blockchain Mediator	Provider enables blockchain integration for explicit blockchain use.
			Blockchain User	Business model itself builds on blockchain.
		Blockchain Sourcing	External Blockchain Use	Provider uses existing blockchain.
			Own Blockchain	Provider creates own blockchain.
			Blockchain Combination	Provider combines different blockchains.
			Existing Blockchain modified	Provider modifies an existing blockchain.
		Blockchain Type	Public	Offered blockchain publicly available.
			Consortium	Offered blockchain available for predetermined group of users.
			Private	Offered blockchain available after registration.
		Underlying Blockchain	Bitcoin	Use of Bitcoins blockchain infrastructure.
			Ethereum	Use of Ethereum blockchain infrastructure.
			Others	Other blockchain than Bitcoin or Ethereum.
			Several	More than one blockchain solution.
		Consensus Mechanism	Self-Created	Implementation of own consensus mechanism.
			Existing	Usage of existing consensus mechanism.
			Modified	Usage of existing modified consensus mechanism.
	Additional Technology		*IoT*	Business Model builds on IoT technology.
			Dapps	Business Model builds on distributed apps.
			Cloud	Business Model builds on cloud technology.
			Big Data Analytics	Business Model builds on big data analytics.
			None	No additional integrated technology within Business Model.

Table 11 Definition of Characteristics: Value Capture

Value Capture	Revenue Stream	*Customer Charge*	Free	Free of charge for customers.
			Regularly Fee	Customer charged by regularly fee.
			Cost per Transaction	Customer charged with transaction costs.
		Currency Acceptance	Solely own Token	Distribution of solely own tokens.
			Additional other Cryptocurrency	Distribution of own tokens and acceptance of other cryptocurrencies.
			Additional Fiat-Currency	Distribution of own tokens and acceptance of fiat currencies.
			Additional Fiat- and Cryptocurrency	Distribution of own tokens and acceptance of fiat currencies and cryptocurrencies.
			No Currency in Blockchain	No trading within business model and thus no currency existing.
		Token System	No Token	No tokens exist.
			Own Token Listing	Business model lists one type of own tokens.
			Dual Token System	Business model lists several own tokens.
			No Token Listing	Business model lists no own token although own token exists.
	Cost Structure	*Provision Cost*	Platform Provision	Providing a platform only without supporting software.
			SDK Provision	Operator provides source code.
			Software Provision	Operator provides blockchain with supporting software.
		Network Sourcing	External Blockchain Use	Business model uses external blockchain infrastructure.
			Own Mining Network	Business model uses own blockchain infrastructure.

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Appendix F. Business Model Innovation Strategies for Product Service Systems – An Explorative Study in the Manufacturing Industry (P6)

BUSINESS MODEL INNOVATION STRATEGIES FOR PRODUCT SERVICE SYSTEMS – AN EXPLORATIVE STUDY IN THE MANUFACTURING INDUSTRY

Research paper

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Abstract

In saturated, product-oriented markets, services provide the potential for differentiation and growth. Innovating a firm's business model (BM) by adopting product service systems (PSSs) seems promising. However, research provides only limited insights on how manufacturing firms can innovate their BM towards offering PSSs. Literature lacks strategies not only to adopt PSSs, but also to further innovate existing PSS BMs. Therefore, this study analyzes reoccurring PSS BM patterns as well as innovation strategies to transform from one pattern to another. We use an explorative, qualitative study with interviews in 14 business units of large manufacturing corporations that are engaged in a PSS BM innovation initiative. Results show three PSS BM patterns, i.e. product-oriented manufacturing, use-oriented enabling and result-oriented service offering. We demonstrate their practical implementation and further derive a conceptual framework for PSS BM innovation describing six evolutionary or transformative innovation strategies. Evolutions, i.e. universalization, digitization and service expansion, change only modules of a BM, whereas transformations, i.e. servitization, integration and leapfrogging, affect the whole architecture. Limitations are the small number of interviews and related limited number of cases. Nevertheless, findings indicate transformation paths and extensions to existing research on PSS types regarding the customization and ownership of PSSs.

Keywords: Product Service Systems, Business Model Innovation, Innovation Strategies, Qualitative Study.

1 Introduction

As saturation of product markets increases, services offer great potential to access new revenue streams and increase competitive advantage (Forkmann et al., 2017, Cusumano et al., 2015, Wise and Baumgartner, 1999). Fang et al. (2008) show a positive effect of a service-oriented strategy for firm value regarding Tobin's q ratio. Qualitative studies confirm that shifting from product to service offerings open up new possibilities like enhancing the value chain position, innovation potential and customer value (Tukker, 2004, Ulaga and Reinartz, 2011, Visnjic Kastalli et al., 2013, Tukker, 2015).

Examples can be found in the information technology industry where product prices have fallen and manufacturers have shifted to service offerings, for example, Dell, IBM or SAP (Cusumano et al., 2015). In the automobile industry, manufacturers have achieved much of their revenue with services, for example, leasing, loans, repairs and maintenance (Cusumano, 2010). A specific example is Xerox. They introduced a Pay-as-you-use model. Customers only pay per printed page and where Xerox, as printer experts, would operate the printer as a service and ensure its availability (Chesbrough, 2010). As a lot of responsibility and the ownership of the product stays with Xerox, this example shows even more opportunities for shifting from product sales to service offerings.

Servitization describes this shift of manufacturing firms that continuously offer more product-oriented services (Vandermerwe and Rada, 1988) and how they build revenue streams (Baines et al., 2017). Research evolved from analyzing the adoption of services for product-oriented business models (BM) to the integration of both products and services (Durugbo, 2013, Barquet et al., 2013, Tukker, 2004). The combination of products and services is called *Product Service Systems* (PSSs) (Goedkoop et al., 1999). PSS research focuses on how both components can satisfy customer needs as a marketable set (Reim et al., 2015).

The process of adopting PSSs (i.e. Servitization) can be seen as a business model innovation (BMI) (Storbacka et al., 2013). BMIs are "designed, novel, and nontrivial changes to the key elements of a firm's business model and/or the architecture linking these elements" (Foss and Saebi, 2017, p. 216), whereas a BM "describes the design or architecture of the value creation, delivery, and capture mechanisms" (Teece, 2010, p. 172). Both concepts receive increasingly attention in research and practice (Massa et al., 2017, Foss and Saebi, 2017, Böhm et al., 2017).

However, only a few studies address servitization from a BMI lens. Most research analyzes servitization in general or service infusion, i.e. the adoption of PSS BMs (Barquet et al., 2013, Forkmann et al., 2017). Literature addresses characteristics of BM elements for successful adoption of PSSs (Kindström and Kowalkowski, 2014, Maglio and Spohrer, 2013, Reim et al., 2015) or their internationalization (Zähringer et al., 2011). Other papers investigate the impact of servitization on firm performance (Visnjic Kastalli and Van Looy, 2013, Visnjic Kastalli et al., 2013, Visnjic Kastalli et al., 2016).

Research still lacks supporting frameworks or methods for PSS BMI (Morelli, 2006, Tukker, 2004, Reim et al., 2015, Neely, 2008, Barquet et al., 2013). Especially research on BMIs itself is missing (Cook et al., 2006, Dimache and Roche, 2013). Reim et al. (2015) and Kindström and Kowalkowski (2014) point out the lack of research on the organizational transformation, particularly from a service point of view. In addition, studies demand more practical contributions (Goedkoop et al., 1999, Ulaga and Reinartz, 2011, Tukker and Tischner, 2006) as well as conceptual analyses concerning PSSs and BMI (Velamuri et al., 2013, Adrodegari et al., 2016).

There is little research combining PSS streams and BM streams (Velamuri et al., 2013). For characterizing PSS BMs, the literature provides different taxonomies either using PSS types or business model patterns (BMP) (Adrodegari and Saccani, 2017, Tukker, 2004, Wise and Baumgartner, 1999). Although Reim et al. (2015) show how PSS characteristics shape BMs; empirical research is missing. Research lacks empirically grounded frameworks from an integrated view of PSSs and BMPs. Withal, a BMP is an abstractly or generally described BM instance or part of it that has proved to be successful in the past (Gassmann et al., 2014, Amshoff et al., 2015, Remané et al., 2017). Thus, BMP is a suitable concept to describe and support PSS BMs.

Overall, current research slightly addresses the adoption of PSS BMs. However, current studies do not include PSS BMPs and transformation strategies among these PSS BMPs. In other words, current research lacks support for further innovating an already adopted PSS BM and only marginally addresses its adoption. Thus, this paper investigates the following two research questions:

1. What are reoccurring business model patterns for product service systems in the manufacturing industry?
2. What are strategies for business model innovation among these business model patterns for product service systems in the manufacturing industry?

Accordingly, we consolidate PSS BM types from literature and investigate their implementation in practice using an explorative, qualitative study with 14 business units of 10 large manufacturing corporations. Further, we deduce BMI strategies among these PSS BMPs.

For this research objective, we first consolidate three PSS BM types from literature (section 2). Subsequently, the paper elaborates on the research method as an explorative, qualitative study (section 3). The following result section first presents the implementation of PSS BMPs (section 4.1). Second, we show the six PSS BMI strategies and derive a framework (section 4.2). Section 5 discusses the results. Finally, we summarize findings and emphasize implications for research and practice, limitations, and avenues for future research (section 6).

2 PSS business model types

Tukker (2004) proposes a classification based on a spectrum of characteristics of either product or service orientation. This point of view does not focus on product business as a starting point, but shows a product service continuum (Windahl and Lakemond, 2010). Tukker's (2004) classification covers a broad range of PSS cases. The majority of PSS research uses this classification as a starting point for (Dimache and Roche, 2013, Annarelli et al., 2016, Durugbo, 2013, Barquet et al., 2013). Reim et al. (2015) expand the PSS classification of Tukker (2004) by analyzing how a firm's BM changes when implementing a certain PSS type.

Tukker (2004) and Reim et al. (2015) derive three PSS BM types. In the following, we characterize these BMs regarding the institutional logics of Lusch and Nambisan (2015), i.e. goods-dominant and service-dominant logic. Figure 1 provides an overview of identified PSS BM types and their relations to institutional logics.

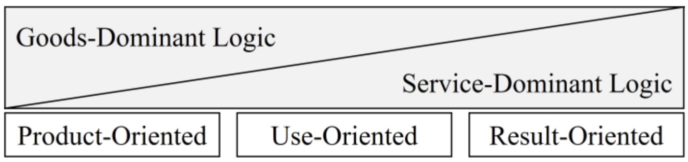

Figure 1. PSS business model patterns adapted from Tukker (2004) and Reim et al. (2015)

The *product-oriented* PSS type by Tukker (2004) and Reim et al. (2015) represents the first PSS BM type. This concept is based on a product that is bought with additional services. Thus, the ownership is transferred to a customer. Product-oriented services deliver secondary value. With this combination of products and services, firms can optimize internal processes and position themselves externally as a cost leader based on standardization. The functional features deliver the core value of the product. Additionally, the low price is another characteristic promoting sales. Services provide additional value. This PSS BM type mainly follows the goods dominant logic as a mental model in organizations (Lusch and Nambisan, 2015, Vargo and Lusch, 2004).

Second, Tukker (2004) and Reim et al. (2015) introduce the *use-oriented* PSS type, where the use of a good shall be promoted by combining products and services. Providers of this PSS BM type allow for customers' product use by applying their service, which increases risks and responsibilities. Tukker (2004) and Reim et al. (2015) further emphasize that a product is made available for usage without transferring the ownership. Examples are product leasing, renting or pooling (Tukker, 2004), so that a customer pays periodically (Reim et al., 2015). The pattern is based on a strong integration of products and services over the lifecycle (Aurich et al., 2006). Accordingly, this BM type is both product and service focused and, hence, covers parts of a goods-dominant as well as a service-dominant logic (Lusch and Nambisan, 2015, Vargo and Lusch, 2004).

The third PSS BM type according to Tukker (2004) and Reim et al. (2015) is *result-oriented*. In contrast to use-oriented, this type focuses on providing a solution. It is not about selling a product but offering a service to solve an issue (Visnjic Kastalli et al., 2013, Aurich et al., 2006, Parida et al., 2014). Products are substitutable tools used in the activity of problem solving. Providers take responsibility for an entire customer problem and are integrated into a customer's organization. As part of the value chain, the firm provides a defined output as a service without selling products. The firm is paid according to the result. Hence, this PSS BM type follows the service-dominant logic as a mental model in organizations (Lusch and Nambisan, 2015, Vargo and Lusch, 2004).

3 Research method

In order to investigate PSS BMs and their transformations, we conducted an exploratory, qualitative study in the context of manufacturing firms. We adjust our research to guidelines of a multiple case study according to Yin (2014). We used the consolidated PSS BM types as a theoretical frame (section 2). In this way, we show how the theoretic BM types apply in practice and investigate their transformations.

For the sampling of cases, we selected 10 large corporations in the manufacturing context and associated 14 business units (i.e. cases) that currently innovate or recently innovated their BM. We chose the firms and related business units in a way that all three PSS BM types are covered and that a broad range of branches is included. All firms represent large enterprises in Germany with employees ranging from 1,000 to 140,000.

Branch	Expert/ Case	Position	Experience	Interview duration	PSS BM
Defense	A	In-Service-Support Manager	6 years	27 min	(R)
	B	Project Manager	6 years	24 min	(U)
Electronic production	C	Product Manager	6 years	35 min	(P)
	D	Project Manager	6 years	24 min	(P)
Propulsion systems	E	Innovation Manager	1 year	35 min	(P)
	F	Head of Innovation Management	10 years	31 min	(P)
Plant engineering	G	Service Manager	6 years	39 min	(U)
	H	Head of Strategic Development	2 years	68 min	(U)
	I	Head of Technical Development	10 years	68 min	(U)
Hygiene industry	K	Product Manager	2 years	38 min	(P)
	L	Product Manager	2 years	34 min	(R)
Power generation	M	Sales Engineer	6 years	39 min	(U)
Automation systems	N	Head of Innovation Management	2 years	27 min	(P)
Construction machines	O	Head of Corporate Strategy	4 years	68 min	(R)

Table 1. Overview of case studies, (P) Product-oriented manufacturing, (U) use-oriented enabling, (R) result-oriented service offering

We qualitatively conducted expert interviews according to Myers and Newman (2007). We selected interviewees that were involved in BMI initiatives (e.g. corporate strategy, strategic development, business development, innovation management or product/service management). The interviews rely on a semi-structured guideline with open questions to capture specific characteristics of each case. The interview guidelines covered three aspects: the initial BM, the transformation and the achieved BM. The interview language was German. Interviews were face-to-face or by phone. Table 1 shows an overview of selected cases and interviews including their duration.

For data analysis, we recorded and transcribed all interviews. We coded the interviews according to Corbin and Strauss (2014) using the qualitative data analysis software MAXQDA. Our coding concept is based three phases of BMI (i.e. initial BM, transformation and achieved PSS BM). Within these three given categories, we used, first, an open coding approach. Keywords of the transformation includes motivation, challenges, related reasons, aspects of the transformation process and practical insights. Second, we used an axial coding based on the dimensions of the *Business Model Canvas* by Osterwalder and Pigneur (2010) as recommended by Massa et al. (2017) or Zott et al. (2011). Two authors were involved in the coding: One author directly coded the interviews and both iteratively revised the keywords. The coding resulted in 29 keywords and 649 phrases.

4 PSS business model innovation framework

Based on the observed PSS BMIs and the corresponding PSS BMPs, we refine existing taxonomies of PSS BMs for manufacturing firms and demonstrate PSS BMI strategies (i.e. transformations and evolutions). Additionally, we highlight extensions to leading PSS concepts like Tukker (2004) and Reim et al. (2015), especially regarding the ownership concept, and integrate constructs in a PSS BMI framework.

4.1 Implementation of PSS business model patterns

	Product-oriented manufacturing	Use-oriented enabling	Result-oriented service offering
Value proposition	High-quality, cost-effective components and integrated and functional products	Custom products and expert knowhow as a service to operate and maintain products	Customer results as a service, products as substitutable tools
Revenue model	Sell a functional good	Sell product-service hybrid	Sell result
Customer base	Industrial firms, price-sensitive, globally sourcing	Industrial firms, highly complex and individual needs	Industrial firms, requirement of maximum cost transparency or with volatile demand
Customer interaction	Until point of sales	Until point of sales, during operation and for maintenance	Throughout customer lifecycle
Transfer of product ownership	Yes	Yes	No
Degree of product standardization	High	Low	High

Table 2. Business model patterns for product service systems

In the following, we show how the three PSS BM types based on Tukker (2004) and Reim et al. (2015) result in three BMPs in practice. We propose specifying the PSS BM debate to certain industries as we observe variances from our data in comparison to the use-oriented PSS type according to Tukker (2004) and Reim et al. (2015) in terms of ownership transfer and standardization. Table 2 shows the details of these three patterns. It shows only a few dimensions of the Business Model Canvas by (Osterwalder and Pigneur, 2010) or variances of it. Omitted dimensions did not significantly separate the BMPs.

PSS BMPs	2nd tier	1st tier	Direct Customer Contact
Result-Oriented Service Offering			A, L, O
Use-Oriented Enabling		M	B, G, H, I
Product-Oriented Manufacturing	C	D, E, F	K, N

Table 3. PSS business model patterns and value chain position of cases (A-O)

We further found different positions in the value chain in the cases (see Table 3). Direct customer access is essential for PSS BMs since providers co-create services with customers (Wise and Baumgartner, 1999, Reim et al., 2015, Lusch and Nambisan, 2015). All observed cases show the characteristics of a PSS BM, as even highly product-oriented manufacturers offer product-related services.

Product-oriented manufacturing

Based on the product-oriented PSS type and the data, we illustrate the PSS BMP of product-oriented manufacturing. *Product-oriented manufacturing* is a traditional BM focused on delivering goods with respect to their development, production, integration and sales. From our observations, we differentiate between two subtypes of this PSS BMP.

The first type focuses on the manufacturing of parts and components in a cost-effective way based on high volumes and high quality (cases C and D). The next step along the value chain after their production is to sell their goods to firms integrating these components into products/solutions, for example, simple control components like switches that are assembled into next tier control systems (case C). For their customers, the firm delivers high-quality, cost-effective components based on their production capability. As their customers can source from globally competing providers at similar quality levels, they show price sensitivity. Even though cases also provide basic services like repairing or overhauling, this is no key selling point (case C). However, these customers also face the issue of minimum order quantities, as they need to purchase only few of various components. An example is the need to source electronic control units for final product assemblies. Customers have the choice between multiple unit-types and the problem of minimum order quantities, even though they need only a few of each type for their own assembly (case D).

The second type is a product manufacturer integrating parts and components into complex systems being the architect and final assembler (cases E, F, K and N). The more complex system requirements appear, the closer they have to work with customers, for example, in the production of gearshifts for public transport bus fleets (case F). Product manufacturers have more visibility towards the end customers than parts and components producers do. These cases show service aspects as part of the pre-sales-phase to understand the customer's requirements, for example, into which type of bus the gearshift is integrated (case F). Nevertheless, there are further steps along the value chain between the producer and the end customer, for example, complex sales processes and after-sales services. Within this value chain, product manufacturers take over the role to translate customer requirements into system architectures to finally assemble and sell them, for example, small batch series of maritime motors (case E). The customer base expects integrated and functional products that deliver high value for their own value chain.

To conclude for both subtypes, customers collaborate with these product-oriented manufacturers until the point of sales and before they contact third-party service experts for the major after-sales activities. In general, we describe this as a product-oriented BMP that focuses on the value chain especially until the point of sales. We observe a few service options (i.e. product-oriented services) along the use phase. Even though maintenance activities are available, no case of product-oriented manufacturing confirms providing extensive pre-sales services (e.g. financing contracts) or major after-sales services (e.g. supply of consumables). We find that these services require resources, logistic capabilities and sales channels that do not exist (so far) for product-oriented manufacturers. Eventually, this PSS BM shows the existence of a *traditional product sales model* (Vezzoli et al., 2015) or *product sales* (Fang et al., 2008, Wise and Baumgartner, 1999). It remains on a goods dominant logic (Vargo and Lusch, 2004).

Use-oriented enabling

Use-oriented enabling is based on the PSS BM type use-oriented and represents a BMP intended to ensure the availability of goods for customers (cases B, G, H, I and M). Providers become an essential part of the supply chain, even though the product fully stays under the control of the customer. Firms offer products for sale with integrated interfaces or other options, so they can always monitor the necessity of maintenance activities. They source these products and add enablers (e.g. IoT-solutions as connectivity functions for goods). This enables remote steering and creates the basis for use-oriented PSSs. Delivering hydropower generation turbines and maintaining them remotely with expert knowhow is a key element of case M. Another example are engineer-on-premise contracts. Case G does not just plan and build plants, but also sends service experts to the customer's production plant to launch operations and ensure 24/7 availability. Corporations, like case G, profit from their strong technical knowhow for their service activities and enable seamless operations for the customer. IT resources help to partly automate expert knowledge and improve processes. Finally, customers can use their assets to solve their problems while being supported by the use-oriented enabler (Visnjic Kastalli et al., 2013, Aurich et al., 2006, Parida et al., 2014). This BMP focuses on both the product and the customer's use of it. These BMs customize, sell and integrate products and provide a lifecycle-oriented support service. In practice, project-based PSSs implement use-oriented enabling. The enabler supports the customer throughout the whole lifecycle from the planning into operations with a customized solution, ensuring the usability of the goods. In case B, they integrate mobile shelter solutions and deploy them for their customers. Nevertheless, their customers own and operate them.

In contrast to Tukker (2004), we propose that firms rely on a hybrid product of service and sales instead of leasing, renting or pooling. We observe three major reasons for this. First, industrial investment goods incorporate a significant financial value. Keeping this as one's own asset would strongly influence the financing structure of a firm. In case M, turbines reflect about one quarter of the whole project volume of their customers, with a medium-sized turbine being around €5 million of €20 million in project volume. With a total tangible asset value of around €400 million on the balance sheet, renting would strongly increase long-term financing needs. Second, customized investment goods include the expertise of the customer, as it is tailored to its processes, recipes or further intellectual property (IP). Transferring the ownership of such a good relieves the expertise at the customer's site as part of his competitive advantage. In case H and I, customers are tire producers, for example. The implemented processes in their facilities build on their highly secret rubber processing and recipes. If the use-oriented enabler keeps the production plant as an asset, this would imply they take away IP from their customer. Third, product and service organizations often work together as separate units (Fang et al., 2008, Visnjic Kastalli et al., 2013). In case M, product sales and after-sales services are organizationally subdivided into separate business units. Nevertheless, they continuously use more synergies by improving their use orientation. This challenges use-oriented enablers to maintain a sales strategy as opposed to disrupting their organization. Despite these variations, we do not see the cases as product-oriented PSSs since customers need provider services to operate these customized products. Thus, the service aspect is essential in this PSS BMP, in contrast to product oriented PSSs according to Tukker (2004) and Reim et al. (2015), where the services provide only additional value (e.g. expanding the supply chain with services or take-back agreements). Thus, use-oriented enabling integrates both goods- and service-dominant logic (Vargo and Lusch, 2004, Lusch and Nambisan, 2015).

Result-oriented service offering

Third, we use result-oriented PSS BM types and findings from the cases to derive result-oriented service offerings as a pattern. Result-oriented service offerings create results as a service by integrating products and services as a hybrid service (Aurich et al., 2006). This model helps customers as firms deliver results as part of the customer's supply chain (cases A, L and O). These result-orientated service providers are independent of selling investment goods or good-related services. In contrast to product-oriented manufacturing, this BMP works in close contact with the end customer and accompanies him throughout his value production. Case A conducts complete drone flight missions for their customers, for example. Service providers cover a value creation step for their customers similar to outsourcing providers. In contrast to other BMs, service providers do not transfer the ownership of a good but deliver everything needed as a bundle and ensure not just the availability of goods, but also the result of their operation. Case L offers a pay-per-wash concept for industrial warewashers. The firm owns, operates and maintains the warewashers including the refilling of required chemicals. To provide this, result-oriented service offerings rely on standardized goods as part of the PSS. They offer two major advantages. They profit from scale effects, so they source these standardized goods cost-effectively from third-party providers. Construction machines of case O, for example, are sourced from a hardware partner who focuses on the efficient production of these goods. For results as a service, the brand or type of the good are almost irrelevant. Assets become a substitutable tool in this scenario. Standardized goods also deliver an ideal base for evaluating product-related data. Being an operator of a fleet for several customers, provider offer a powerful database to learn and optimize operations. This enables transparency for result-based contracting. The pay-per-wash provider can learn from hundreds of parallel operating hours and improve their diagnostic capabilities for preventive and corrective maintenance.

The customer base of result-oriented service offerings requires a high degree of transparency and flexibility. One part of customers of case L are streamlined gastronomy services that appreciate to reduce the risk of machine downtime to a minimum plus reducing assets. Furthermore, precise pricing helps them to improve their financial planning. Another customer segment consists of young food entrepreneurs that cannot afford to invest in expensive warewashers. A result-oriented BM helps to overcome this former market entry barrier due to its flexibility. A third group of customers prefers result-oriented service offerings in the case of volatile demands to capture exceeding capacity. In alignment with Tukker (2004), we characterize this PSS BMP as similar to outsourcing providers, but with a strong integration into the customer's value chain. Eventually this PSS BM is based on a service dominant logic (Lusch and Nambisan, 2015).

4.2 PSS business model innovations strategies

We observed different approaches how firms innovate their BMs. We propose two types of BMI strategies and differentiate them according to the degree to which a firm's BM is changing, i.e. *Business Model evolution* and *transformation*. For differentiation, we build on Foss and Saebi (2017) who categorize BMIs into *modular* and *architectural* according to the scope. An architectural change is a fundamental change to the architecture of an existing BM, which we call a *Business Model Transformation*. A *modular* change refers to an optimization adapting specific modules of a BM, what we call a *Business Model Evolution*. We see both as sub concepts of a BMI. In the following, we illustrate all six BMI strategies using the dimensions of the Business Model Canvas (Osterwalder and Pigneur, 2010).

PSS business model transformations

We differentiate between *Servitization* in a narrow sense, *Integration* and *Leapfrogging* as transformation strategies for PSS BMs. *Servitization* helps to innovate a product-centric business concept by adding service opportunities. This refers to all components of a PSS BM (Storbacka et al., 2013). As product margins become more unattractive (Wise and Baumgartner, 1999, Spring and Araujo, 2013), the main driver for this transformation is to profit from downstream services that can be provided based on the expert knowledge of the manufacturer. We see *Servitization* within the PSS BMI framework in a narrow sense as a BMI from *product-oriented manufacturing* to *use-oriented enabling*.

As the focus of this business changes from producing and selling a good to enabling the use of it, the value proposition shifts. Cases B and M, for example, shift to ensuring entire operations and logistic capabilities for production plants instead of solely selling them. Consequently, key activities change by integrating servicing activities and interfaces to the product organization. Firms do not just manufacture and source product parts, but also integrate them into a service concept. Additionally, new resources (e.g. (servicing) skills, toolsets, etc.) extend the portfolio of key resources to provide, for example, operational maintenance (case G or H). Either former partners for downstream operations, such as after-sales service providers, are integrated into the BM or existing partners enter a new role as strategic partners, for example for spare parts management. Finally, servitization affects the channels and relationships to customers. In contrast to contact limited to the point of sales, the relationship expands throughout the whole product lifecycle, for example, not just in fields of maintenance, but also in operations, customer training and further after-sales (case B). This creates the need to expand the customer channels and to build a sustainable infrastructure to maintain them. Further, servitization implies an extension of income streams to service activities formerly owned by pure service providers. New cost structures include an increased resource base to maintain product and service business (case G and H). Eventually, this transformation also influences customers. Earlier, only customers with the capability to operate goods throughout their product lifecycle were attracted, whereas this BM transformation relieves the risk of ensuring the availability. To conclude, servitization offers the transformation from *product-oriented manufacturing* to *use-oriented enabling*.

The second transformation strategy, *Integration*, relates to integrating products and services into a result-oriented service that focuses on customers' key problems. The driver of this business is to overtake even more risks of a customer and charge a risk premium. This risk of failure decreases by continuously monitoring and operating one's own goods for the customer. The combination of risk premium and included service fee offers attractive income opportunities, while the customer receives a comfortable result as a service solution. Thus, we define *Integration* within the PSS BMI framework as a BMI from *use-oriented enabling* to *result-oriented service offering*.

This BM transformation refers to all components of the BM. The value proposition is not limited to enabling a customer to use his goods; it shifts to ensure the solving of a customer problem. A massive extension of the key resources is needed to offer a viable solution. In case O, for example, a fleet of construction machines needs to be maintained to offer construction site operations. Resources have to be expanded by goods that formerly have been part of product sales and the value proposition. In this concept, they become tools of this BM enabling the solution. This implies that the good's ownership remains with the provider. Instead of being part of the customer's assets, they add on the resource of the firm. Additionally, activities changed to create a result instead of enabling customers to use products. This has an impact on the culture of a business towards a customer-centric organization. Moreover, former partners are integrated. They do not just deliver value on a parallel value chain. They become strategic partners supplying the firm with what they need to attain a certain result as a service (e.g. hardware partners). Shifting the strategic relevance from a supplier to an essential part of a customer's value chain intensifies the relationship. Modes of communication channels become part of the BM's value chain. Integration as transformation affects the income structure from product and service sales to service sales based on results. This BM transformation also changes the cost structure, as the firm has to cover new resources and more activities. This leads to increased capital and personnel costs, for example. Finally, integration attracts new customers that face a lack of competences or resources concerning a certain aspect of their value chain. Accordingly, this transformation is relevant for use-oriented enablers combining their products and services to result-oriented service offerings.

Leapfrogging is the third type of BMI we observe. This describes the BMI from *product-oriented manufacturing* to *result-oriented service offering* without transforming towards *use-oriented enabling*. We found only one case conducting Leapfrogging (Case L). The key driver of this transformation is to capture completely new customer groups by disrupting the business offerings. The value proposition of such a BM shifts from high-quality, functional products to the creation of a result, by combining the use of products and corresponding services. Case L shifted from building and selling warewashers using a third-party sales force to selling cleaned dishes directly. They set up dishwashers at a customer place, fully maintained them and provided consumables. Customers just start the machine on demand. The formerly product-oriented manufacturer has to set up new resources including service personnel and finance machines for the integrated product service provision. In addition to this extension of key resources, the service provider has to expand key activities by everything in relation to the lifecycle-oriented customer care and servicing. Furthermore, new partners complete the portfolio that offer consumables for operating the goods. In contrast to formerly limited sales channels, they implemented new processes to manage the customer lifecycle for end customers. Two major groups extend the customer base. The first group requires cost transparency as a core value and prefers to adjust their asset dependency by receiving the results on demand. The second group avoids market entry barriers by choosing to purchase results on an operational basis instead of assets on an investment basis. Especially for new market entrants, this offers the chance to start flexibly. The cost structure shifts from a production-focus to a service-focus. This influences personnel costs for servicing and increased customer care. Furthermore, the transformation comprises an additional assets load on capital costs. On the income side, there is new potential due to service fees including their risk premium offer and recurring revenue. Instead of selling machines at low margins, case L uses their extensive knowhow to provide results. As remote maintenance solutions enable the optimization of these services, they create attractive business opportunities.

PSS business model evolutions

In contrast to drastic changes of BMs, we observe adaptions of individual BM modules focusing on the product or the service of a corporation. We call these kinds of BMIs *Evolutions*, as they illustrate the shift to closely related BM characteristics within a PSS BMP. Evolutions often help to realize transformations as small steps of them.

We differentiate evolutions based on their surrounding PSS BMP. However, we only found evolutions in two of three patterns, i.e. *product-oriented manufacturing* and *use-oriented enabling*. *Universalization* is the first adaption of product-oriented manufacturing. It describes the standardization of a product portfolio (Schilling, 2000) and increases the products' application potential.

Universalization influences the BM as it relieves the pain of customizing parts or components, which exposes major R&D and organization efforts. A second main driver of *Universalization* is to increase sales opportunities by improving the product-market fit and opening up novel use cases due to universal application scenarios. In case D, modularizing and standardizing help to turn a wide portfolio of specific electronic control units into few multi-purpose units. This supports existing product-oriented manufacturers to focus their strategic value proposition and to offer a broader usage range of their standardized parts, components and products. The service offering changes similarly. Still, providers offer only basic services like repairing and overhauling. However, with increasingly standardized products, the basic services also become less diverse. The BM evolution does not affect the partnering base or key resources. It helps to decrease efforts that have been part of key activities, for example, the management of variations of goods (case C). On the opposite, the potential customer base increases. Wider ranges of use cases for modular and standard products help to explore new markets or customer segments, as the products can be used for multiple purposes. *Universalization* does not change channels or relationships. By optimizing internal processes due to a reduced product portfolio, the firm can reach cost optimizations. The income side varies due to reduced prices and higher sales volume. To conclude, *Universalization* does not change the BM as drastic as transformations but helps to sharpen the value proposition that affects several BM components.

In contrast, *Digitalization* includes creating and opening interfaces to capture and control good-related data and, thus, build the foundation for further business opportunities (Yoo et al., 2010). This is the basis for adding services based on data, including remote maintenance or other comfort features. Digital transformation strategies of product-oriented manufacturers drives this BM evolution. A digitalized product also allows for interfaces to external platforms and ecosystems of offerings. Thus, we see *Dig-*

italization within the PSS BMI framework in a narrow sense as a BM evolution focusing the digitalization of products.

Digitalization helps product-oriented manufacturers to enable further service offerings. New product features add up in functionality as a value proposition. Case E, for example, equips maritime motors with telematics solutions. Opening digital interfaces certainly affects the partner base and requires new key resources, as the capturing of produced data needs an enhanced infrastructure. This demands an extension of suppliers for digital components. Furthermore, the portfolio of activities extends. It creates demand for new skills and tasks to manage new product characteristics. Moreover, channels and relationships profit from digital input or automated processes showing strong synergies with new service options. Digitally oriented customers can become a new target group. The base of digitalized products offers the potential to implement further services and, thus, additional income. To conclude, R&D efforts and digital components increase the cost side. Overall, *Digitalization* itself enables additional services and changes the BM evolutionarily. Often it is the first step to servitization, as digital interfaces to one's products allow for the selling of PSS bundles.

Starting from *use-oriented enabling*, a *Service Expansion* is an evolutionary BMI. Firms extend the service portfolio and implement new service structures in order to capture more attractive downstream offerings. This includes lifecycle-oriented offerings, for example, to not just maintain goods at a certain point in time, but also support ongoing operations with expert knowhow (case G). Use-oriented enabling already ensures the availability of a good. A *Service Expansion* provides even more services for customers. In contrast to *Servitization*, *Service Expansion* takes place within the BMP *use-oriented enabling*. The provider already offers a PSS where services enable the usage of a product.

Service Expansion leads to the adaption of a more product-lifecycle-oriented service attitude, which improves the service value. As part of this evolution, the firm adds new features, for example, the utilization of data from digitalized products or the integration of formerly downstream service tasks. The evolution affects the partner base, as some partners become competitors within the after-sales segment. The portfolio of activities and resources extends by new service resources and skills to realize new service features. These adaptions marginally influence customer base, relations or channels. However, new services offer new sales opportunities and affect revenues. Due to higher personnel costs to perform the corresponding tasks, costs rise. Eventually, this evolution is used to focus one's own BM towards a stronger service portfolio.

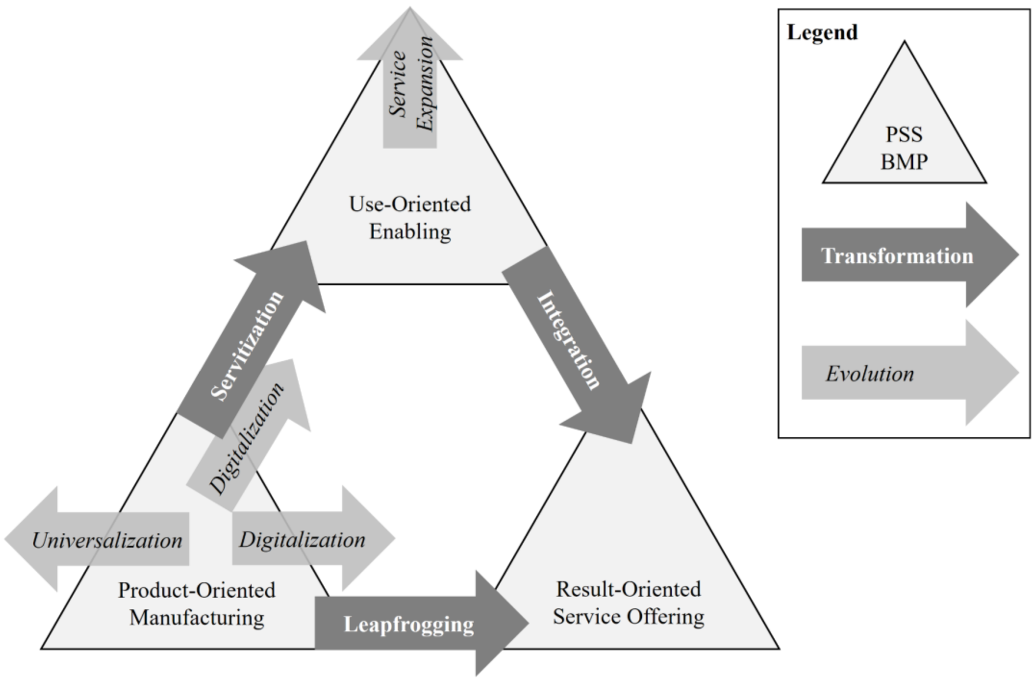

Figure 2. Business model innovation framework for product service systems

Figure 2 shows the PSS BMI framework summarizing strategies and relations to PSS BMPs. It illustrates the three transformations and their relations to patterns as well as the three evolutions. *Digitalization* can be a first step towards *Servitization* as well as towards *Leapfrogging*. *Universalization* and *Service Expansion* do not directly contribute to a transformation strategy. However, they can sharpen the focus of the BM.

5 Discussion

We derived three BMPs based on PSSs as an operational core of a BM from literature and demonstrated their implementation in practice. They focus on either a goods- or service-dominant logic or a combination of them. We further split strategies of the overarching concept of servitization (Baines et al., 2017) in six PSS BMI strategies, i.e. three transformations as structural innovations and three evolutions as BM adaptions. In the following, we discuss theory extensions and integrations in relation to identified PSS BMP and PSS BMI strategies.

We found extending characteristics in comparison to agreed PSS classifications especially in the context of ownership transfer of use-oriented PSSs. The results indicate an additional subtype of use-oriented PSSs according to Tukker (2004) and Reim et al. (2015) with a transfer of product ownership due to three main issues: IP, standardization and customization, and financial impact on firm structures. Customized goods contain IP, which customers prefer to own. Further, customized goods offer less potential for reusability and scalability. Standardized, connected goods provide similar data to learn from, which facilitates the calculation of result-based fees. Customized goods lack this potential. Thus, standardized goods are more suitable for result-oriented BMs than customized goods. Whereas Tukker (2004) shows the applicability of these concepts for use-oriented purposes, we found that customized goods (e.g. hydropower turbines) are less likely to be operated on a result basis, whereas standardized goods (e.g. commercial dishwashers or printers) can be tied to result-oriented contracts. Additionally, customized goods are rather sold than rented if they represent a significant financial value for both parties, provider and customer.

Building on PSS BMPs, some identified PSS BMI strategies apply known concepts in literature. The PSS BM evolution universalization uses standardization and modularization. Standardization enables the exploitation of economies of scale (Farrell and Saloner, 1985). Further, modularity allows for an increased number of options to utilize a product (Sanchez and Mahoney, 1996). Universalization shows how PSSs use these concepts to enable economies of scale for standardized products and basic services. In addition, the PSS BMP result-oriented enabling shows a trend towards using economies of scale based on rather standardized products.

Digitalization in this paper is related to digitization as a general BMP (Gassmann et al., 2014) and the trend of digital transformation, which receives increasingly attention in research and practice (Hess et al., 2016, Fitzgerald et al., 2014). Digitalization as a PSS BM evolution shows how PSSs can digitally transform products and, thus, implement the general BMP. Product-oriented manufacturers digitally equip offered products to build the foundation for new BMs.

Regarding PSS BM transformations, only one case conducted leapfrogging. We see leapfrogging as an exceptional transformation that exposes an organization to high effort and risk. It transforms the value proposition from products to services and disrupts the financing structure. New value chain steps also influence activities and resources. Further, result orientation requires direct customer access. Thus, leapfrogging seems like a major change that opens change gaps in various parts of a BM. The dominant strategy transforms to use-oriented enabling first, before offering result-oriented services. For result-oriented service offerings, goods-related options are out of scope since goods are substitutable. We found no BMI strategies here. Overall, the transformation paths indicate how strategic options of BMI are dependent on the firm's initially followed BMP.

6 Conclusion

We demonstrate that PSSs and BMs conceptually form PSS BMs. We show how a combination of products and services interrelates as an operational core of a BM. Based on Tukker (2004) and Reim et al. (2015) as well as an exploratory study, we propose PSS BM types and their practical implementation as PSS BMPs. The three patterns are *product-oriented manufacturing*, *use-oriented enabling* or *result-oriented service offerings*. Second, we reveal six BMI strategies. Three strategies innovate the BM evolutionarily (i.e. universalization, digitization and service expansion) and three innovate it transformatively (i.e. servitization, integration and leapfrogging). Thus, we identify strategic paths of firms and derive the PSS BMI framework.

Our research has several implications. For research, we, first, addressed the call for more detailed research on PSS BMPs from Adrodegari and Saccani (2017) and Annarelli et al. (2016). Further, the PSS BMI strategies show transformation paths within the PSS BMPs as recommended by Velamuri et al. (2013) and Adrodegari and Saccani (2017). We recommend building on this PSS BMI framework. Research can be based on a clear differentiation of evolutions and transformations. Both BMI concepts have a structurally different impact and imply different strategic opportunities. Second, we extend PSS types according to Tukker (2004) and Reim et al. (2015) with PSS BMPs. Identified patterns are especially suitable for the manufacturing industry with respect to their characteristics, i.e. capital intensity for industrial investment goods, IP and customization and standardization. We additionally demonstrate a use-oriented PSS type with ownership transfer, which extends prevailing theories of Tukker (2004) and Reim et al. (2015).

For practice, we demonstrate PSS BMI strategies in forms of evolutions and transformations. We further illustrate strategic paths with different cases. Based on the strategic position within an existing value chain, firms can use our framework and example cases to support decisions regarding BMI. Furthermore, identified PSS BMPs support managers in evaluating their own BM and in analyzing their strategic fit of products, services and their BM. Additionally, we reveal preconditions, challenges and opportunities for each pattern.

The findings are subject to limitations. Results are explorative and qualitative. We conducted one interview for each of the 14 business units as first, explorative research. Findings are limited to ten examples of the business-to-business manufacturing industry in Germany. However, several cases confirm each identified BMP and each strategy, except for leapfrogging (case L only).

Several avenues for future research emerge from the findings. First, future research should clarify how the evolutions and transformations of PSS BMs affect financial performance. Second, we did not find cases in our data where customized goods offer potential for scalability. However, technologies like 3D-printing enable customized goods as part of a product-oriented BMs. Third, we could not find any evolutionary BMIs in the pattern of result-oriented service offerings. Future research should focus on this pattern since it also requires significant organizational changes. Fourth, researchers should challenge the BMI strategy of leapfrogging. We observed this as a unique transformation that bears potential for future research. Overall, future research can build on the findings of this paper with further analysis on rare patterns and transformation strategies as well as quantitative analyses.

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Appendix G. Practices for Open Business Model Innovation – An Innomediaries Perspective (P7)

Practices for Open Business Model Innovation – An Innomediaries Perspective

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Abstract. Innovative business models generate competitive advantage and are becoming more important than innovative products or processes. Despite its importance, firms continuously fail to innovate business models. Reasons are inhibiting structures, cultures and missing resources or capabilities. Integrating external stakeholders can help to overcome these barriers. Turning to innovation intermediaries, so-called "Innomediaries" support firms. Innomediaries specialize on the integration of suppliers, customers, or inventive partners (startups or universities) into innovation projects. With three in-depth case studies, we provide an actionable framework for integrating external stakeholders into business model innovation. It guides firms when, with whom, and how they can integrate external stakeholders to reduce risks and accelerate the creation of innovations. We shed light on the understudied intersection of open innovation and business model innovations and the linking role of innomediaries. Future research can extend the role of IT, protection against opportunistic behavior, and innomediaries as service platforms in innovation ecosystems.

Keywords: Business Model, Open Innovation, Innovation Intermediary, Case Study.

1 Introduction

An innovative business model generates competitive advantage [1–3] and is becoming more important than innovative products or processes [4]. A business model describes how value is created, delivered, and captured [5], and business model innovation is a rising topic in the literature [6]. Firms often leverage new digital technologies to innovate their business model [7, 8]. For example, traditional manufacturers use digital technologies to increase service offerings with servitization strategies [9, 10]. Daimler AG, for instance, innovated from traditional product sales to mobility services and short-term renting with car2go as a leader in car-sharing [11].

Firms fail to innovate business models for many reasons [11, 12]. Barriers erect inhibiting structures, cultures, capabilities, and resources. Firms' values and processes might spur product innovation but hamper business model innovation [13]. Traditional industries might lack digital capabilities and resources for transformations [14].

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Integrating information, resources, needs, requirements, and perspectives of external stakeholders' can mitigate inhibiting structures and cultures and enables access to new resources and capabilities, which aids in creating viable business models [15, 16]. Firms that lack the capabilities or resources to integrate external stakeholder turn for assistance to innovation intermediaries. As specialists in managing innovation and integrating stakeholders, these innomediaries [17, 18] integrate expertise from suppliers, customers, or inventive partners (startups or universities). They support business model innovations and become "central to creating and maintaining a successful innovation ecosystem" [19].

Previous studies disregard how innomediaries facilitate open innovation [20] and integrate external stakeholders (suppliers, universities, startups, even potential competitors) into business models innovation [21]. Most contributions focus on one particular stakeholder group and neglect integrating several ones [22, 23]. If, when and how firms integrate other external stakeholders, such as suppliers, universities, startups, or even (potential) competitors in innovation projects is rarely investigated. Scholars have called for more research on innovation projects' frameworks [24, 25]. Research on multilateral stakeholder relationships remains sparse [26]. Similarly, little attention has been given to the process of designing business models [21]. Thus, extant research seldom guides business model innovation.

This study fills that gap in the literature with an actionable approach for integrating external parties into business model innovation, that is "open business model innovation". We address the following research question:

RQ: How can firms integrate external stakeholders in business model innovation?

We build on three in-depth case studies of German innomediaries that specialize in supporting firms to succeed in business model innovation by linking them to external stakeholders. We structure their activities into distinct phases and describe how and when they involve external stakeholders in their clients' deliberations.

The result is a framework for planning, monitoring, and controlling stakeholder integration during business model innovation. The framework with its activities and practices of innomediaries contributes to open innovation and business model literature. For practice, it guides practitioners toward when and how to integrate external stakeholders into business model innovation. Results can further apply to other customer-centric, open, innovation projects.

2 Related Work

To analyze business model innovations and external stakeholder integration, we first define main concepts and have a look at extant work on business model innovation, open innovation, and different modes of stakeholder integration. Following a common definitions, we understand a business model as "the design or architecture of the value creation, delivery and capture mechanisms employed" [5] and business model innovation as "designed, novel, nontrivial changes to the key elements of a firm's business model and/or the architecture linking these elements" [3].

As practices for external stakeholder integration differ concerning the phases of innovation processes, we had a look at different process models for business model innovations [27–30]. As basis for our research, we chose a high-level widely applicable process model: the 4i-framework [31]. It covers four process phases of business model innovation: initiation, ideation, integration and, implementation. First, initiation, is about the ecosystem analysis. This phase aims at, first, understanding the needs of all players involved including customers and users, and second, to identify possible drivers of change, which include technology trends and changes in markets and business environments [31]. Second, ideation, firms generate business model ideas. Identified stakeholder needs and change drivers from the first phase are transformed to tangible business model ideas. It is important to think out of the box and overcome industry standards [31]. Third, integration, contains the actual building of a new business model. Business model ideas from the preceding phase are used to develop profound and comprehensive business models. Central aspects are integrating all business model elements, i.e., value creation, value delivery and value capture [5], as well as the management of partners for business model implementation [31]. Fourth, implementation, the business model is implemented. It is important to overcome internal resistance with open communication so that all stakeholders understand and support the new business model. The phase typically includes experimentation with pilots and trial-and-error [31]. Overall, the four phases do not form a linear process. They rather imply iterations within and between themselves. Thus, we can use is as a flexible basis to analyze and describe practices for open business model innovation.

To analyze and add integration practices to business model innovation, we have a look at open innovation literature. Global competition leads to rising costs in research and development (R&D) and technology as well as shorter product life-cycles, which requires firms to open their innovation processes towards open innovation [32, 33]. With open innovation firm integrate external expertise, e.g., from suppliers or customers. Open innovation covers various innovation activities, such as buying or licensing technology, hosting innovation contests, or forming R&D alliances or joint ventures with the help of innovation intermediaries [33]. An open innovation strategy changes traditional business models to open business models [32, 33]. Open business model innovation seeks and exploits the ideas of stakeholders outside the innovating firm [32] and, thus, integrating different external stakeholders. A stakeholder is "any identifiable group or individual who can affect the achievement of an organization's objectives or who is affected by the achievement of the organization's objectives" [34].

We found three different modes of stakeholder integration in literature: *Passive integration*, *reactive integration*, and *active integration* [35, 36]. *Passive integration* is about integrating external stakeholders without their awareness with no active communication between stakeholders and the investigating party. This mode covers identifying stakeholder needs, ideas or requirements and conducting market analyses or ethnographic studies, such as netnography or empathic design. In *reactive integration*, investigating firms invite external stakeholders to give feedback about or evaluate ideas, concepts, prototypes and uses, or further specify their needs and requirements. Reactive integration uses methods, such as surveys or concept testing. In *active integration*, external stakeholders are equal partners an innovation project to jointly solve and discuss a problem. An active dialog and development of new ideas, concepts, or prototypes characterizes this mode. Typical methods are a co-creation workshops or open platforms, such as innovation communities, where stakeholders develop their own ideas and concepts and can act independently from the organization.

However, discussed contributions give a rather high-level guidance and mainly focus on customer integration without considering other stakeholders. Further, innovation intermediaries and the specific context of business model innovations is not addressed. Thus, this paper investigates practicable approaches for stakeholder integration in business model innovation from the expert perspective of innovation intermediaries.

3 Research Method

For exploring innomediaries and their integration practices of external stakeholders into business model innovation projects, we chose a case study approach [37]. To obtain rich results from innomediaries in their natural setting, we choose multiple cases based on interviews and secondary data [37].

Table 1. Case Studies and Interviews

Firm	*EE*[1]	*Est.*[2]	*Expert*	*Duration*	*Position*	*Years*[3]	*Projects*
StartupCo	250	2010	Expert A	75 min	Partner	2,5	≈15
			Expert B	62 min	Senior Project Manager	2,5	5
			Expert C	65 min	Senior Project Manager	2,5	6
NetworkCo	125	2008	Expert D	64 min	Project Manager	3	≈15
			Expert E	63 min	Senior Project Manager	2,5	15
			Expert F	68 min	Innovation Consultant	4	13
CrowdCo	100	2000	Expert G	47 min	Managing Director	15	≈100
			Expert H	66 min	Senior Innovation Consultant	3	≈15

EE[1]: Employees (appr.); Est.[2]: Founding year; Years[3]: Working years at the innomediary

We interviewed eight executives of three German innomediaries that specialize in integrating external stakeholders into business model innovation projects. We used the following selection criteria: (1) Firms routinely integrate external stakeholders in business model innovation projects. (2) They are established, comparatively large innomediaries. (3) They do not specialize in a specific industry. (4) They offer consulting and project management. These inclusion criteria ensured that our sample is appropriate to help answer our research question and to minimize the risk of investigating the wrong cases.

We selected interviewees based on their professional expertise, e.g., the number of managed projects and years of work experience. Sources that support triangulation of data [37] include semi-structured in-depth interviews with executives and employees and follow-up with e-mails and phone calls, corporate materials, Internet sources, and business publications. Table 1 shows the firms, interviewees, and their experience.

The interview guideline consists of 15 primary questions (i.e., demographic, knowledge, and experience) and various follow-up questions [38]. Experience questions capture information about past observations or actions of the interviewee. Knowledge questions relate to the accumulated knowledge of the interviewee and do not necessarily include own experience. Demographic questions gather background information about the interviewee. The questions were adjusted after the first interview [38]. We interviewed five experts face-to-face and three by phone. A snowball method was employed [39], where interviewees recommend additional interviewees of the firm.

We transcribed the interviews and secondary data and coded them with MaxQDA [38]. We used several coding approaches to obtain different perspectives about the data i.e., value coding, process coding, descriptive coding and holistic coding [40]. We derived 783 codes and grouped them into smaller categories and subcategories to synthesize initial summaries of data segments. We extracted all quotes about external stakeholder integration, its mode, and its method. We identified patterns—repeated behaviors, actions, norms, and routines—for both single and multiple cases and assigned them within the 4I-framework [31].

4 Results

4.1 Three Innomediaries

The three innomediaries we interviewed typically form teams of their employees and clients to provide comprehensive support throughout the innovation process. They integrate external stakeholders, including suppliers, experts, freelancers, partner organizations, customers, and users.

StartupCo emphases collaboration with startups. Its global network of firms, incubators, accelerators, and partners lets it connect the right people at the right time and place, including founders of tech firms, political decision-makers, and other influencers. A dedicated division develops startups and establishes startup pilots. StartupCo supports later stages of business model implementation, including go-to-market. This distinguishes it from our two other case companies, which typically exit projects after delivering a validated prototype or minimum viable product (MVP).

NetworkCo maintains networks of marketing services and private networks. As part of a global group of marketing service firms, NetworkCo can directly search and solicit personnel as needed. Its project managers use private networks and public websites to identify experts and freelancers. NetworkCo has extensive experience with social media and digital technologies. Its consumer integration methods are typical of digital marketing, such as focus groups, product clinics, and online analysis.

CrowdCo employs open innovation methods (e.g., crowdsourcing) and relations with universities to develop ideas. CrowdCo runs its own platform for crowdsourcing whereby people generate and develop ideas, concepts, and solutions. CrowdCo provides additional toolkits to support development of the crowd's ideas and to improve results. For very specific cases, CrowdCo exchanges tech knowledge with competitors.

Although these firms differ, all share principles, processes, and methods for integrating external stakeholders. All three take a lean-startup approach—that is, test assumptions quickly, learn from findings, and repeat. Client work primarily involves reactive and passive integration. The most-used modality of reactive integration is face-to-face surveys. Passive integration includes market studies and ethnography, including empathic design and netnography. The primary active integration modality is co-creation workshops with external stakeholders, such as startups, experts, customers, and users. NetworkCo builds on focus groups, whereas CrowdCo uses lead-user workshops. CrowdCo goes beyond workshops to sponsor communities of ideas, contests, and innovation toolkits.

4.2 Integration Methods in Open Business Model Innovation

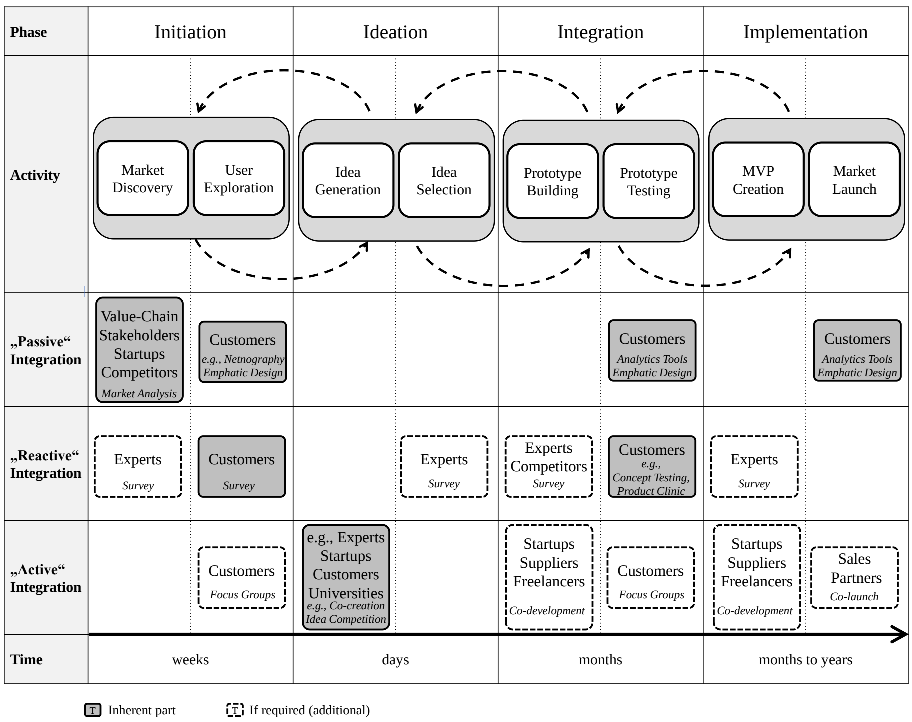

Figure 1. Framework for External Stakeholder Integration in Business Model Innovation

The three interviewed innomediaries employ integration methods that can be grouped into eight activities within four phases. We structured our findings within the four phases of the 4I-framework for business model innovation [31]. We added a time-component to denote and weight phases by importance. Our results guide open business model innovation by specifying its four phases, their duration and sequence, and eight activities and their integration methods (Figure 1).

The three modalities of stakeholder integration are *passive*, *reactive*, and *active* [35, 36]. Passive integration identifies external stakeholders' needs, ideas, or requirements without their awareness through market analyses or ethnographic studies (e.g., netnography or empathic design). Through surveys or concept testing, reactive integration solicits external stakeholders' comments about ideas, concepts, prototypes, and incorporates their needs and requirements. Active integration involves external stakeholders as equal partners through dialog and development of ideas, concepts, or prototypes. Typical methods are co-creation workshops and open platforms where external stakeholders develop ideas and concepts without influence from investigators.

Initiation. During the initiation phase the three innomediaries acquire knowledge to underpin subsequent activities. They "focus on the understanding and monitoring of the surrounding ecosystem of the innovating firm" [41]. *Market discovery* and *user exploration* dominate this phase. Market discovery analyzes internal and external elements of the status quo such as the client's current business model, strategies, and core competencies. External analysis examines the client's value network and screens technologies and market trends. All interviewed executives agreed that both must be part of the initial innovation process. To understand new technologies, StartupCo, for example, uses informal meetings and interviews with external experts. Market discovery includes market analyses, surveys, or interviews. Passive integration of startups and (potential) competitors, i.e., startup screening uncovers ideas and market trends:

"First, the focal firm, the competition, and the entire market have to be analyzed to show where digitization is taking place in the industry and to identify relevant starting points for innovation." (Expert D)

"The most valuable currency for innovation are startups. Why? Startups work exclusively on new, future-oriented business models – otherwise, it would not be a startup. Furthermore, any startup which got seed or series A funding has already convinced a lot of people and investors." (Expert A)

For user exploration, the three innomediaries identify the explicit and latent needs, desires, discomforts, habits, and routines of their client's customers through netnography, surveys, surveys, contextual face-to-face interviews, and customers focus groups.

"A very detailed understanding of the customer is generated. This entails the understanding, structuring, and processing of customer needs and problems." (Expert B)

Ideation. The ideation phase encompasses *idea generation* and *idea selection*. The former generates novel, applicable ideas [42] to *"quickly generate as many ideas as* *possible"* (Expert A). This activity converts opportunities into ideas for new business concepts. Idea generation is not a sequence of steps but a stream of different co-creation workshops and idea competitions with experts, startups, customers, and universities:

"For example, we do crowdsourcing within our innovation community. Along with a co-creation workshop where we include, for instance, customers. At the same time, we organize a second workshop with students from our partner universities. The ideas from these strands are then clustered and prioritized." (Expert H)

Active methods reveal information about clients' needs, solutions, and leading-edge information based on their implicit and tacit knowledge. Integrating external stakeholders into interdisciplinary teams expands perspectives on problems and solutions. Integrating stakeholders generates commitment and willingness to participate in other projects:

"We involve the client [into ideation workshops] and give them the feeling of being part of the project." (Expert A)

During idea selection, all three innomediaries emphasize small internal teams aided by external experts. Larger teams increase the likelihood of disagreement and endless discussions. Team selection depends less on members' creativity and more on their business sense. All three innomediaries invite or consult external experts for checking technical feasibility if specific technologies are involved.

Integration. During the integration phase our three interviewed innomediaries develop and test ideas from the ideation phase and transform them into viable business models. In addition, firms approach necessary partners and integrate them into further development. All three innomediaries take the *lean-startup* approach to launch products, firms, and business models [43]. It entails swift experimentation, customer feedback, and short development cycles with rapid prototyping and hypothesis testing. Accordingly, the integration phase consists of *prototype building* and *prototype testing*.

Customer integration quickly indicates whether solutions match identified requirements and prompts quick adjustment of business models. Relations with potential partners are important, especially during later stages of integration, when instantiating prototypes and business models require external help. Here firms integrate startups, experts, and suppliers for specific capabilities. StartupCo, for example, co-develops prototypes with partner organizations, i.e., startups or suppliers. For specific problems, they use external experts. CrowdCo, for example, outsources the development of specific prototypes. Freelancers can overcome resource bottlenecks. Existing solutions, services, or products can be tested with direct reactive methods:

"It is about creating something very fast, something that can be assessed and is tangible. Then, one must enhance the object in several iterations until one has a final product." (Expert G)

"Prototypes can be tested independently and without our intervention, for example, with simple websites where we track and monitor the behavior of the users or we walk the customer through the prototype and subsequently conduct interviews." (Expert C)

Implementation. After integration validates ideas and concepts, innomediaries support clients to implement business models. This phase involves extensive risks and investment [44]. To mitigate them it is advisable to conduct trial-and-error market experiments with an MVP. MVPs originated in Silicon Valley, where tech firms sought ways to innovate faster. An MVP generates business models with limited features to test in real-life settings. By testing different features, innomediaries and their clients evaluate new ideas and functions, learn market responses, and fine-tune business models:

"Finally, the ideas are implemented in the form of a so-called minimal viable product. This is a first marketable, a first testable product or product generation, which can then be further 'rolled out' or scaled after a successful market test." (Expert B)

"We then build small, new organizations that do not have to follow existing rules. Such a new organization is the pilot of a business concept. Subsequently, there is some form of testing and validation. This cycle is repeated as often as necessary." (Expert F)

Similar groups of external stakeholders participate in integration and implementation. However, integration builds and tests prototypes and features, whereas implementation creates and launches a business model. Co-development and co-launching with startups, suppliers, freelancers, or sales partners can mitigate risks of implementation. Building close, durable business relationships is more important during implementation than in other phases.

All in all, different phases of business model innovations show different integration methods and diverse stakeholders. Customers typically contribute heavily in early phases with their problems and ideas, as well as in later phases with prototype feedback. Universities as partners contribute with ideas and emerging technologies. Startups and suppliers are typically involved in co-development of prototypes. External experts are invited and consulted with regard to specific technologies. Additionally, communicating with competitors can support levering specific technologies. Figure 1 summarizes open business model innovation activities and practices.

5 Discussion

Integrating external stakeholders in business model innovation initiatives is crucial for their success [16]. To deepen our understanding how and when to integrate whom, we analyze innomediaries as specialists in this area. Three case studies show how and when innovation intermediaries integrate external stakeholders into innovation projects. We identify eight activities (i.e., market discovery, user exploration, idea generation, idea selection, prototype building, prototype testing, MVP creation, and market launch) and related stakeholder integration practices (e.g., market analysis, netnography, survey, focus groups, and co-development) that are relevant for stakeholder integration. Cases integrate external stakeholders either reactively or passively. In reactive integration, surveys in the form of face-to-face interviews are the most commonly disseminated method. In passive integration, popular methods are market studies or ethnographic techniques, such as empathic design and netnography. Active integration most often uses co-creation workshops with internal staff and external stakeholders, such as startups, experts, customers, and users. Idea communities, idea contests, and toolkits for innovation are also used. However, the method of stakeholder integration changes with the phase and activity of the business model innovation.

This study has two main limitations. First, the findings are based on eight interviews in three German innomediaries, which has implications for the study's generalizability. The number of cases does not provide generalizable results, which was not the aim of this qualitative case study. The sampling strategy includes only German firms. In more open or closed cultures, the integration of external stakeholders might be different from our findings. Moreover, the limited number of interviews restricts the findings. However, we used rich secondary data and interviewees with substantial experience to migitate this issue. Besides, the sample includes innomediaries only and no other incumbents or startups, what leads to innomediary-specific results. However, innomediaries are particularly experienced with the management of open business model innovation projects and integration of external stakeholders, other incumbent firms might not, particularly in traditional industries. Second, qualitative research are generally prone to response and observer biases [37]. Response biases include a wide range of cognitive biases such as positive leniency and social desirability [45]. In this case, experts may have influenced answers regarding the practice of integrating external stakeholders. Data triangulation, though, mitigates this issue. These limitations aside, the provided framework and related best practices are valuable contributions, because they build on three international, well-reputed innomediaries and experience from hundreds of business model innovation projects.

5.1 Contributions to Literature

This study contributes to open innovation and business model innovation literature in two ways. First, the perspective of innomediaries enriches the open innovation literature. While previous studies mainly focused on one stakeholder group, i.e., customers, analyzing innomediaries enables us to expand this perspective. As innomediaries are specialists in boundary spanning between actors in innovation ecosystems, their perspective augment open innovation with additional stakeholders, such as suppliers, universities, startups, or even potential competitors. We present how and when business model innovation projects integrate external stakeholders. Innomediaries further introduce new methods that can support open innovation, i.e., MVP or lean-startup. This broader lens to open innovation paves the way for new research and reveals a new level of analysis. For example, the ecosystem as a unit of analysis in platform literature allows scholars to examine phenomena from high-level perspective [46, 47]. This moves the field from a dyadic firm-customer relationship to theories spanning organizational boundaries. The findings illustrate that the concept of innomediaries is important and worthwhile to study.

Second, our study enhances business model innovation research. Our research extends the existing 4I-framework [31] and shows practices of innovation intermediaries and related stakeholder integration in business model innovations. The results specify tangible practices and activities for each phase of business model innovation and combines it with open innovation. Therefore, our contribution lies in combining both research streams and making sense of their intersections and commonalities. Doing so reinforces the concept of ecosystems as units of analysis for business model innovation, which involves multilateral stakeholders beyond the firm's boundaries. Finally, from an ecosystem perspective, the business model innovation approach provides fruitful connections and generalizable findings to the domains of product, process, service, and organizational innovation.

5.2 Practical Implications

The framework in Figure 1 guides practitioners toward when and how to integrate external stakeholders into business model innovation and applies to other customer-centric, open, innovation projects. The framework emphasizes intermediaries because they guide entire business model innovation projects, can accelerate innovation, and access networks of entrepreneurs, professionals, and potential partners. Following are guidelines for considering stakeholders.

Integrate users and customers, especially during early stages and prototype testing. Users and customers should be integrated into the initiation, ideation, and integration phases (especially prototype testing) [41]. Passive methods, (netnography, empathic design), reactive methods (surveys, contextual face-to-face interviews), and active methods (co-creation workshops, idea competitions) are most suitable. Integrating users and customers into prototype testing is at least as important as early-stage activities. Users and customers provide better input when ideas are mature enough to be presented visually [48]. Reactive methods (concept testing, product clinics) and active methods (focus groups) fit best, as do passive methods like analytic tools and empathic design. Integration throughout the innovation phase builds commitment and willingness to participate in future innovation projects [49].

Invite customers, startups, experts, and universities during ideation. To generate meaningful or disruptive ideas, it is important to summon a mix of stakeholders. Integrating startups, experts, and university students can soften entrenched structures, transform dominant cultures, and provide new capabilities that expand perspectives and ideas. Experts can endorse the technical feasibility of ideas, concepts, and prototypes and facilitate understanding technology. Suitable methods are active: co-creation workshops and idea competitions. Co-creation workshops with university students can be a cost-efficient means of generating innovative ideas.

After selecting an idea, approach partners early and work with them closely. Firms should integrate partners (suppliers, sales associates, competitors, startups, experts) when they lack capabilities to develop ideas further. Three aspects are important. First, firms typically approach potential partners late in the integration phase and early in the implementation phase. Here, first prototypes are validated [50], and expansion of a novel business model requires added help and capabilities. Active methods (co-development, co-launch) best suit partner integration. Additional expert surveys and interviews as reactive methods can shape the MVP.

Second, if it is readily apparent that implementing an idea requires external partners, they should be approached as early as possible to accelerate innovation [51]. An early approach creates shared visions and group identities, develops mechanisms to prevent opportunistic behavior, and elicits information and resources for further development. An early approach also supports close and long-term partnerships with suppliers instead of simple buyer-seller relationships. Active methods (e.g., co-development workshops) and reactive methods support early integration of partners.

Third, build on innomediaries as partners. They can access expertise and networks of potential partners and thereby accelerate innovation, which is pivotal for competitive advantage [52]. They are experts about when to integrate whom, and how in business model innovation. Innomediaries facilitate innovation ecosystems beyond the firm.

6 Conclusion and Future Research

Integrating external stakeholders is crucial for successful business model innovation [16]. This study has produced an actionable framework for integrating stakeholders into business model innovation based on in-depth case studies of innovation intermediaries engaged in that purpose. Case studies of three German innomediaries identified three modes (passive, reactive, and active), five hands-on methods (market analysis, netnography, surveys, focus groups, and co-development), and eight activities (market discovery, user exploration, idea generation, idea selection, prototype building, prototype testing, MVP creation, and market launch) for integrating external stakeholders into business model innovations.

To understand when to integrate, with whom, and how in open business model innovation, we investigated innomediaries as specialists in this area. The innomediaries integrate external stakeholders actively, reactively or passively, depending on the phase of the project. Customers generally are integrated, reactively and passively, at the start of a project before prototypes exist, whereas potential partners are approached during later phases of development after prototypes exist. Face-to-face surveys are common method of reactive integration. Market studies or ethnographic techniques (empathic design, netnography) are preferred methods of passive integration. Active integration often involves co-creation workshops with internal staff and external stakeholders (startups, experts, customers, users). In addition, idea communities, idea contests, and toolkits for innovation are promising. This article provides recommendations on how and when to integrate which external stakeholders into business model innovation to reduce risks and speed up innovations.

For future research, we see three areas: First, research can investigate the role of IT in external stakeholder integration for business model innovations. Our results already show on the one hand that digital technologies heavily support collaboration and indicate towards digital co-creation. On the other hand, we can see that digital business model innovation projects requires a greater variety of stakeholders and, thus, increases complexity. Future research can build on these findings and show how more or less *digital* products and approaches changes open business model innovation. Second, since this paper is innomediary-specific, future studies can analyze different external stakeholder groups and how they affect the success and innovativeness of the resulting business model. Different stakeholders can have different objectives and perspectives. Successful open business model innovation projects require both, openness and protection against opportunistic behavior. Future research can develop proper incentives as well as governance structures to foster commitment and willingness to collaborate. Third, research can analyze emerging innomediaries, which might build on additional innovation methods, such as design science, design thinking, or design sprints. Research can further investigate how service platforms for innovation ecosystems arise and how they influence business model innovations and success.

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