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OFFERING KNOWLEDGE AS A SERVICE - A TAXONOMY OF KNOWLEDGE-INTENSIVE BUSINESS SERVICES

Christoph Ksouri-Gerwien
Ruhr-Universität Bochum, christoph.ksouri-gerwien@isse.rub.de

Martin Ebel
Ruhr-Universität Bochum, martin.ebel@isse.ruhr-uni-bochum.de

Kendra Bittner
Ruhr-Universität Bochum, kendra.bittner@isse.rub.de

Jens Poeppelbuss
Ruhr-Universität Bochum, jens.poeppelbuss@ruhr-uni-bochum.de

OFFERING KNOWLEDGE AS A SERVICE – A TAXONOMY OF KNOWLEDGE-INTENSIVE BUSINESS SERVICES

Research Paper

Christoph Ksouri-Gerwien, Ruhr-Universität Bochum, Germany, christoph.ksouri-gerwien@isse.rub.de

Martin Ebel, Ruhr-Universität Bochum, Germany, martin.ebel@isse.rub.de

Kendra Bittner, Ruhr-Universität Bochum, Germany, kendra.bittner@isse.rub.de

Jens Poeppelbuss, Ruhr-Universität Bochum, Germany, jens.poeppelbuss@isse.rub.de

Abstract

Servitization describes the transformation of a manufacturer to a customer-centric service and solution provider. Providing customer solutions requires the integration of knowledge from different domains, e.g., engineering, software, and service, and usually also entails that more knowledge-intensive business services (KIBS) become part of the manufacturer's overall business model. Against this background, this article investigates how manufacturing and software firms leverage knowledge in KIBS and corresponding business models. We developed a taxonomy that systematizes KIBS along the three meta-dimensions of value proposition, value creation, and value capture. The application of our taxonomy to exemplary cases from both industries shows different strategies of knowledge usage across these industries. Our findings can support the development of KIBS and help practitioners to understand different ways of utilizing knowledge as a strategic resource. Implications for research point to the need for better understanding the collaboration of multiple actors from a knowledge-based perspective.

Keywords: Servitization, Knowledge-Intensive Business Services, Taxonomy

1 Introduction

"Knowledge is considered to be a special strategic resource that does not depreciate in the way traditional economic productive factors do" (Curado and Bontis, 2006). Knowledge as the object of investigation has influenced many different fields of research and continues to open new research opportunities (Pereira and Bamel, 2021). Following the seminal work of Grant (1996), the main task of an organization is to integrate knowledge, carried by individuals, to create value. Often this is associated with creating new products, services and processes and to bring these to markets and societies. However, firms from the manufacturing industry today face unprecedented challenges as their existing business models are called into question (Kohtamäki et al., 2019). In particular, the trend of servitization raises the "importance of providing solutions rather than products" (Parida and Wincent, 2019, p. 3). Servitization described as the transformation of formerly product-oriented firms to advanced service or solution providers with a strategic focus on service (Favoretto et al., 2022) has gained further traction through digitization (Coreynen et al., 2017; Weking et al., 2020). In this context, knowledge as a strategic resource (Curado and Bontis, 2006) plays a crucial role (Valtakoski, 2017) when firms progress on their digital servitization journey. Although manufacturing has been considered as a knowledge-intensive industry (Larsen, 2001) for long, it will no longer be sufficient to use this domain knowledge separately from other kinds and sources of knowledge when digital servitization challenges existing business models and industry logics. Instead, it will become increasingly important to bundle knowledge from the different disciplines and integrate it into solutions.

One prime example that already puts knowledge center stage is the field of knowledge-intensive business services (KIBS). KIBS heavily rely on professional knowledge related to a specific (technical) discipline or a functional domain (Hertog, 2000). In the past, KIBS have often been described as knowledge-intensive inputs to the business processes of other organizations (Miles, 2005; Muller and Doloreux, 2007). Within the transformation towards solution providers, manufacturers do not use KIBS solely as inputs, but they integrate such KIBS into their portfolios and become providers of KIBS. Thereby knowledge seems to obtain a new role in the manufacturing firms' business models, which describe their systems of activities that determines the way how value is created by an organization with customers and partners (Amit and Zott, 2012). No longer seen solely as a resource or activity that contributes to value creation, e.g., via product development or service execution, knowledge rather carries the potential for a focal value proposition and hereby becomes a strategic element to communicate potential value to customers (Payne et al., 2017).

For instance, KUKA, an original equipment manufacturer of industrial robots and automation solutions, recently introduced two KIBS offerings enabling customers to operate and maintain their products autonomously. First, KUKA offers a virtual reality-based self-learning system, where customer employees can access training content (knowledge) whenever they need it (Pratticò and Lamberti, 2021). Second, KUKA has deployed XPert (we elaborate on this example in detail in section 4.2), which is a platform where customer employees can access information and solutions to problems for self-support. Intriguing to see is that even corporate firms like KUKA develop such KIBS in cooperation with software companies, e.g., Empolis (Empolis Information Management GmbH, 2022). This tendency towards a joint development with partners from different domains seems to be of growing relevance in the context of servitization and solution development (Anke et al., 2020; Sklyar et al., 2019). While there is the advantage of not having to build up all the required skills and competencies (Münch et al., 2022) in one's own company, stronger collaborations also present challenges in the management of knowledge. Bouncken and Kraus (2013) refer to the process of using knowledge from other parties as "inlearning", which is seen as important for creating new value, but also described as a "double-edged sword" when companies cooperate with their (future) competitors.

With the assumption, derived from the knowledge-based theory (Grant, 1996), that knowledge is the central element for value creation, we assume that accessing knowledge from other domains (i.e., inlearning between manufacturing and software organizations) becomes of utmost importance during the digital servitization of manufacturing. Therefore, our goal is to better understand how knowledge is managed in firms that offer KIBS. We specifically look at mechanical engineering, but also at the software industry as they are usually required as partners when manufacturing firms move forward on their digital servitization journey, e.g., by providing digital services like predictive maintenance and self-service platforms. The software industry is often also considered to be rather advanced providers of KIBS and, hence, a comparison with more traditionally less service-centric manufacturing firms can lead to interesting results. We examine the research question: *How do manufacturing and software firms leverage knowledge through KIBS and corresponding business models to propose value to their customers?*

To address this research question, we conducted a taxonomy building process based on an investigation of cases from the manufacturing industry and the software industry. We elaborate on how firms leverage their knowledge through knowledge-intensive offerings and business models. Our results show that both industries utilize knowledge differently. While knowledge is to a large extant shared free of charge in the software industry to support customers in their value-creation processes, knowledge is rather protected and utilized only by the providers' employees in the manufacturing industry. However, first endeavors to disrupt these dominant logics can be recognized.

Our taxonomy contributes to KIBS and servitization literature by structuring the fundamental constructs and relationships of knowledge in KIBS considering a business model perspective. Thereby, it provides a foundation for further sense-making and theory building (Kundisch et al., 2021) and opens up new research opportunities for investigating multi-actor collaboration for business model innovation from a knowledge-based perspective. As for practical implications, the taxonomy can be used by managers to develop knowledge-intensive offerings and help them understand different leverage strategies of using knowledge as a strategic resource.

In the next section, we introduce the research background in which we conceptualize knowledge as a strategic resource and KIBS as the object of our study. In Section 3, we describe our taxonomy design process. We present the taxonomy with its different characteristics and dimensions and demonstrate its application in two cases of the manufacturing and software industry in Section 4. We close this article with a discussion and conclusions in Section 5.

2 Research Background

2.1 Knowledge as a Valuable Organizational Resource

Organizations can be conceptualized as institutions for integrating knowledge (Grant, 1996). Taking a resource-based view (Barney, 1991), knowledge can be classified as a valuable and rare resource that is difficult to imitate and that ultimately has the potential to create sustained competitive advantage if the organization is capable of utilizing and exploiting on their available knowledge (Barney and Mackey, 2016). Knowledge, however, is "an elusive concept which is difficult to define" (Rowley, 2007). Most scholars specify knowledge with reference to the related concept of information (Rowley, 2007). Information is organized and structured data, which is relevant and useful for a purpose or in a context (Rowley, 2007). Information has to be mixed with individual experience, skills, values and capabilities to form knowledge, which, then, enables one to perform certain actions (Rowley, 2007; Turban et al., 2006). Consequently, knowledge answers the question on how to do something by applying information in a certain context (Ackoff, 1989).

Fundamentally, knowledge can be differentiated into explicit and implicit knowledge (Alavi and Leidner, 2001; Rowley, 2007; Turban et al., 2006). Both knowledge types are interrelated and build the basis for organizational knowledge creation (Nonaka and Takeuchi, 1995). Grant (1996) states that the transfer of knowledge between companies or even within a company depends to a large extent on the type of knowledge. While the transfer of implicit or tacit knowledge is usually very lengthy and costly, explicit knowledge is much more suitable for knowledge exchange.

Early research was mostly concerned with knowledge transfer inside an organization (Nonaka and Takeuchi, 1995; Alavi and Leidner, 2001). However, knowledge is increasingly transferred also beyond the borders of organizations (Ayala et al., 2017). This applies to explicit as well as to implicit knowledge and is positively influenced by digitization. Digital technologies, such as data mining, groupware, communities and many more (Obeidat, 2019) support and enable the storing, creating, transferring and sharing of knowledge, within and beyond organizational boundaries (Alavi et al., 2005; Ayala et al., 2017). For instance, knowledge stored implicitly in an expert's mind can be captured explicitly in a digital organizational knowledge base and, thus, used by others (Barrett et al., 2015; Choi et al., 2010). Technologies such as augmented reality, e.g., in case of remote support, enable implicit knowledge to be transferred and used almost in real time without having to make it actually explicit. Sharing and applying knowledge remotely comes along with economic and ecological benefits (Sousa Jabbour et al., 2018).

2.2 Knowledge-intensive business services

The previous industrial logic in manufacturing mainly reflects a product-centric view on value creation (Kohtamäki et al., 2020), with embodied knowledge being marketed in the form of manufactured goods. Increasingly, a service-centric view is taken, with advanced services and smart solutions as market offerings (Sjödin et al., 2016). The transformation of a manufacturer to a solution provider can thus be described as a shift towards a firm that provides KIBS. KIBS firms primarily accumulate, create, or disseminate knowledge "for the purpose of developing a customized service or product solution to satisfy the client's needs" (Bettencourt et al., 2002). KIBS heavily rely on professional knowledge or expertise related to a specific (technical) discipline or functional-domain (den Hertog, 2000). Thus, KIBS are typically carried out by highly qualified professional employees and are considered laborintensive (Miles et al., 1995; Miles, 2005; Nordenflycht, 2010). KIBS are commonly categorized into two main categories, which are traditional professional services (e.g., marketing, legal services, management consultancy) or new technology-based services mainly related to information and communication technologies and technical activities (e.g., technical engineering, training in new technologies, software development) (Miles et al., 1995; Muller and Zenker, 2001). KIBS provide knowledge-intensive inputs to the business processes of other organizations (Miles et al., 1995) and enable firms in nurturing almost symbiotic relationships with their clients (den Hertog, 2000; Muller and Doloreux, 2007).

Following Vargo and Lusch (2004), such a symbiotic relationship between a KIBS firm and their customers can be considered as value co-creation. In a value co-creation relationship, a solution provider and a client integrate capabilities and resources to form a valuable solution (Vargo and Lusch, 2004). For instance, while the solution provider offers a (digital) product and maintains it (KIBS), the client applies resources to operate it, e.g., employees or infrastructure. Each product or service included in such an integrated solution is to a certain extant rooted in knowledge (Valtakoski, 2017). Thus, integrated solutions can be conceptualized as bundles of different knowledge components. These bundles include "different types of knowledge, including knowledge embodied in physical products, intangible yet codified knowledge, such as software in information systems, and tacit knowledge, such as the know-how of service experts" (Valtakoski, 2017, p.6). Against this backdrop, KIBS are considered as a chance for manufacturing firms to leverage their knowledge in terms of valuable solutions co-created with their clients.

While the original identity of manufacturing should always be considered within the transformation to a solution provider (Huikkola et al., 2021a), there are opinions "that every industrial company in the coming age is also gonna have to be a software and analytics company" (Rose, 2015). However, the software development and analytics capabilities might not be available to the required extent in many traditional manufacturing firms. If a single organization is not capable to manage all knowledge components on its own, the use of strategic partnerships is suggested (Brax et al., 2021). Besides that, external knowledge sharing is generally seen as beneficial for innovation (Ritala et al., 2015). While close collaboration and partnerships are important for a successful transformation (Kamalaldin et al., 2020), strategic collaboration also comes with greater exposure to information and knowledge leakage which makes the management of knowledge indispensable (Tan et al., 2016).

In order to manage knowledge, companies should be aware of the form in which they hold knowledge and whether it is particularly worth protecting (e.g., knowledge with long life cycles). Since there is still little information on the proper use of knowledge in the transformation to a KIBS firm, we intend to create transparency on how knowledge is used in different KIBS. Therefore, it seemed appropriate to on the one hand investigate innovative manufacturing firms that already pursue the KIBS path, and to look at the root KIBS firms, which are providers of information and communication technology, on the other hand. That is, we also investigated software firms providing software products, such as for example 3D-CAD software, and corresponding KIBS, which can be considered as integrated solutions by the means of Valtakoski (2017).

3 Research Methodology

The objective of this research is to better understand how knowledge can be implemented in KIBS and how firms propose value by integrating knowledge into their offerings to their customers. We analyzed cases from two different industries, the manufacturing and the software industry, and built a taxonomy to systematize different KIBS. We used the established procedures according to Nickerson et al. (2013) and Kundisch et al. (2021) for rigorous taxonomy development. We defined the meta-characteristics and built the taxonomy in three iteration cycles, one of them being a conceptual-to-empirical cycle and two following the empirical-to-conceptual approach (Figure 2).

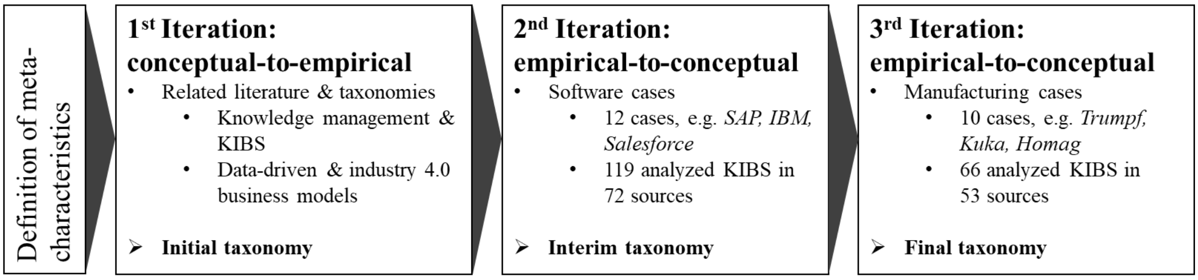

Figure 2. Taxonomy building based on Nickerson et al. (2013) and Kundisch et al. (2021).

The meta-characteristic "specifies the taxonomy's angle on the phenomenon under consideration" (Kundisch et al., 2021, p. 10). Our taxonomy is intended to be used as a framework to analyze and design KIBS and how firms leverage knowledge-intensive offerings within their business models to propose value to customers. Manufacturing firms as one target user group of the taxonomy (Kundisch et al., 2021) are supposed to use it to elaborate on different ways of utilizing knowledge within their transformation to an integrated solution provider. The taxonomy is considered to serve exclusively for actors in the business-to-business market. As integrated solutions transform existing business logics (Kohtamäki et al., 2019), we have adopted a holistic view on business models as the meta-characteristic of our taxonomy. Recent research has found a consensus on three overarching fundamental pillars that help to describe a business model (i.e., value proposition, value creation, and value capture) (Bocken et al., 2014; Gassmann et al., 2014). Hence, we used the three widely accepted business model dimensions (1) value proposition, (2) value creation, and (3) value capture as initial meta-dimensions (MD) and, hence, as the conceptual lens while building the taxonomy (Möller et al., 2021). These MDs have already been used for similar taxonomies, e.g., industry 4.0 business models (Weking et al., 2020).

Based on the MDs, we initiated the taxonomy building process with a first conceptual-to-empirical iteration (Nickerson et al., 2013; left in Figure 2). We formulated an initial set of dimensions and characteristics drawing on literature from related disciplines such as knowledge management (e.g., Nonaka and Takeuchi, 1995; Alavi and Leidner, 2001; Turban et al., 2006) and KIBS (e.g., Miles, 2005; Muller and Doloreux, 2007). Moreover, related existing taxonomies were examined to inform the taxonomy building process (Kundisch et al., 2021), e.g., the industry 4.0 taxonomy (Weking et al., 2020) and the taxonomy for data-driven business models (Hartmann et al., 2016).

For the empirical-to-conceptual analysis (2nd and 3rd iteration in Figure 2) we examined 22 cases of software and manufacturing companies (Table 1). The second iteration was devoted to software companies and the third to manufacturing companies. Offerings within both industries can be considered knowledge-intensive (Miles, 2005; Larsen, 2001). As KIBS are rooted in information and communication technology (Section 2.2) it seemed appropriate to investigate software firms for the first empirical-to-conceptual iteration. All of the analyzed software firms offer digital products (software) and KIBS as integrated solutions. For our case selection, we focused on large corporate firms since we associated these with more sophisticated offerings and thus more valuable input data for the taxonomy development compared to small and medium-sized enterprises (SME). We searched for the top ten software companies based on revenue, which led to, e.g., Microsoft, Adobe, and SAP. Additionally, we screened the members of the *Consortium for Service Innovation™*, e.g., Mathworks, ServiceNow, and PTC, since these firms elaborate on their operationalized knowledge management approaches in publicly available case studies[1]. This enabled us to investigate, in particular, the value creation dimension of the firms and their knowledge-intensive offerings. We categorized each case within the initial taxonomy and, during this process, added, updated and deleted dimensions and characteristics of it. This led to an interim taxonomy.

[1] https://library.serviceinnovation.org/Case_Studies

In the third iteration, we investigated corporate manufacturing firms, such as Trumpf, Heidelberg, KUKA, and Homag, since they have integrated increasingly more KIBS and software components into their solution offerings. Furthermore, we included two SMEs in the sample to which we as researchers, due to the collaboration in a research project, had unrestricted empirical access. We classified each case within the interim taxonomy and comprised taxonomy operations as described in the second iteration. As no major changes in the dimensions and characteristics were made within the third iteration, we terminated the taxonomy development process (Nickerson et al., 2013).

We consulted various secondary sources for our data collection, such as academic articles (■), firms' websites (●), marketing presentations (▲), internal workshop material (△) and the *Consortium for Service Innovation*™'s case studies (◊). In total, we examined and coded 185 KIBS offerings from 22 firms (Table 1). For both industries, a differentiation was made between the KIBS domains of training, consulting, support and maintenance to further structure the kinds of offerings. The analyzed KIBS ranged from standard maintenance and support services of manufacturers to massive open online courses of software firms. For the detailed coding of KIBS, we followed a two-step approach. First, we deductively allocated data to the MDs. Second, we inductively defined dimensions and characteristics within the MDs. To reduce subjective influence in coding, every case was analyzed by two researchers independently using *MAXQDA* software.

No.	Category	Company	Sources	KIBS					
				Training	Consulting	Support	Maintenance	Total	Source Type
1	Software	Salesforce	6	3	1	1	1	6	● ▲ ◊
2		Oracle	8	4	1	3	1	9	● ▲
3		Adobe	4	4	1	3	1	9	●
4		ServiceNow	9	5	1	4	1	11	● ▲ ◊
5		Quest	4	3	1	4	1	9	● ▲ ◊
6		MathWorks	6	7	1	3	1	12	● ▲ ◊
7		PTC	6	5	1	3	1	10	● ▲ ■ ◊
8		Microsoft	9	4	2	5	2	13	●
9		IBM	6	4	2	3	2	11	●
10		SAP	8	5	1	4	1	11	● ■
11		Siemens	4	5	1	3	1	10	● ▲
12		Vmware	4	3	1	3	1	8	▲
13	Manufacturing	Homag	6	2	1	3	1	7	●
14		KUKA	6	3	1	3	1	8	● ■
15		Trumpf	5	3	1	3	1	8	● ■
16		Voith Hydro	9	2	1	2	1	6	● ▲
17		Rexroth	6	3	1	2	1	7	● ▲
18		Bomag	2	2	1	2	1	6	● ▲
19		Phoenix Contact	5	2	1	2	1	6	● ▲
20		Heidelberg	8	2	1	5	2	10	● ▲
21		ACP Systems	2	1	0	2	1	4	△
22		Dreher Automation	2	1	0	2	1	4	△
Total			125	73	22	65	25	185	

Table 1. Sample of firms and KIBS.

4 Results

4.1 Taxonomy

We developed a taxonomy that consists of 11 dimensions and 31 characteristics (Figure 3). The characteristics of the taxonomy are not exclusive, i.e., more than one characteristic can be valid in each dimension. In the following, we elaborate on the dimensions and characteristics of the taxonomy and show its application in two cases of the industrial contexts, namely KUKA Xpert (manufacturing) and MathWorks Community (software).

MD	Dimensions	Characteristics			
Value proposition	Offering	Knowledge application	Knowledge transfer	Embodied knowledge	
	Knowledge domain	Consulting	Maintenance	Training	Support
	Knowledge type	Implicit	Explicit		
	knowledge level	Basic knowledge	Expert knowledge		
Value creation	Knowledge source	Internal	External		
	Knowledge base	Individual	Organization	Community	
	Knowledge agent	Human	Artificial		
	Knowledge channel	Physical	Digital		
	Knowledge transfer	No transfer	Conversation	Information media	Experience
Value capture	Revenue stream	Cost avoidance	Revenue generation	Knowledge	Indirect
	Revenue model	Subscription	Transaction	Free	

Figure 3. Taxonomy of KIBS.

The MD *value proposition* can be differentiated into the four dimensions offering, knowledge domain, type and level. Knowledge might be applied and executed as services through the provider, transferred directly, e.g., in manuals or how-to videos (which implies execution of knowledge-based activities by the customer), or embodied in exchanged products and software. The offered knowledge can be associated to the four domains consulting, maintenance, training, and support. Consulting is mainly attributed to optimization regarding the utilization of the main product or software in the customer environment. Training means educating the customer to purposefully use the main product or software and ranges from initial on-boarding to expert training. Maintenance differs from support in the matter of frequency, i.e., maintenance happens regularly, such as machinery inspections and software updates/bug-fixes, while support happens rather on demand in the sense of troubleshooting. The knowledge type might be implicit or explicit. Often, implicit and explicit knowledge come along within an offering and cannot sharply be distinguished. Last, knowledge level expresses if the exchanged knowledge is rather basic and encompasses or enables simple actions, or if it is rather expert-level knowledge and results in sophisticated actions, for example solving complex problems.

For the MD *value creation*, the dimensions knowledge source, base and agent as well as channel and transfer are relevant. Knowledge can be sourced internally from the employees or externally from customers contributing to a community. The knowledge base defines how knowledge is stored or maintained. This can be either an individual, e.g., an employee with his or her mental model, an organization, which might operate an organization-wide knowledge management system, or a community, e.g., a forum on the company homepage. The knowledge agent accesses the knowledge base and extracts the required content based on situational factors. This can be achieved either by a human being, e.g., an employee searching for the right content, or an artificial assistant, as for example a chatbot. Regarding organizational knowledge bases, in particular, these two characteristics often occur together, since nowadays knowledge management systems are equipped with increasingly intelligent artificial search assistants that support employees by providing the right knowledge even for unspecific search requests like, e.g., “clacking at the bearing of machine XY”. Knowledge can flow through a physical channel, e.g., the employee’s hands while executing a service or a written manual, or through a digital channel like a how-to-video or a digital manual. It can be transferred through conversations, e.g., a call between customer’s and provider’s employees, information media, e.g., documents and videos, or via the experience of seeing and imitating an action. In some instances, no knowledge is transferred, e.g., in case of regular maintenance or software updates where knowledge is applied to the product/software without a learning experience for the customer.

The MD *value capture* is differentiated into the two dimensions revenue stream and revenue model. The offering can aim at revenue generation or cost avoidance, or in achieving additional knowledge, e.g., in a community. It can also result in indirect effects such as customer satisfaction and cross-/up-selling. Knowledge revenue models include transactional, subscription-based or free-of-charge modes.

4.2 Taxonomy demonstration in two cases

In order to illustrate the taxonomy’s utility as a tool to analyze knowledge-intensive offerings and business models we elaborate on two KIBS examples from the manufacturing and software industry, which are both relevant to the servitization context. In line with Gassmann et al. (2014), we consider the analysis of existing offerings and business models as an essential innovation activity that inspires the design of new ones. In the following, we categorize the two examples according to the taxonomy’s dimensions and characteristics.

The first offering is Xpert which was recently launched by the manufacturing company KUKA (KUKA AG, 2022). We chose this particular case since Xpert can be considered a disruptive example for the manufacturing industry. KUKA is a global automation corporation and supplier of intelligent automation solutions. KUKA offers robots, production cells and automated systems for markets such as automotive, electronics, healthcare, etc. KUKA bundles their products with KIBS such as support services, e.g., on-site support or a 24/7-hotline, employee training, machine refurbishment and so forth. KUKA introduced Xpert as a knowledge platform where KUKA shares information and knowledge with their customers enabling them to accomplish certain actions such as programming, problem-solving, maintenance and conceptual design as self-services. KUKA offers a free version KUKA Xpert basic with limited features and a paid version with additional features.

MD	Dimensions	Characteristics			
Value proposition	Offering	Knowledge application	**Knowledge transfer**	Embodied knowledge	
	Knowledge domain	Consulting	Maintenance	**Training**	**Support**
	Knowledge type	Implicit	**Explicit**		
	knowledge level	**Basic knowledge**	**Expert knowledge**		
Value creation	Knowledge source	**Internal**	External		
	Knowledge base	Individual	**Organizational**	Community	
	Knowledge agent	**Human**	Artificial		
	Knowledge channel	Physical	**Digital**		
	Knowledge transfer	No transfer	Conversation	**Information media**	**Experiencing**
Value capture	Revenue stream	**Cost avoidance**	**Revenue generation**	Knowledge	Indirect
	Revenue model	**Subscription**	Transaction	Free	

Figure 4. KUKA Xpert (paid) categorized according to the taxonomy.

Considering the taxonomy, the KUKA Xpert paid version can be characterized as follows (Figure 4). KUKA Xpert provides knowledge explicitly via a digital platform covering the knowledge domains training (e.g., operating/programming instructions and guidelines) and support (e.g., case database consisting of symptom and cause and solution fits). While the free version KUKA Xpert Basic relies mainly on basic knowledge (e.g., product information and assembly instructions), the paid version of KUKA Xpert offers more sophisticated expert knowledge such as the case database consisting of symptoms and the downloads of code snippets and configurations for solving problems. The knowledge source is considered as internal because technical authors and product experts of KUKA compile and review the knowledge, which is then stored in the organizational knowledge base. The knowledge base is accessed by the customer as a human being, e.g., via the search function in the digital platform. The transfer of knowledge therefore takes place in form of information media (e.g., product information, assembly and operating instructions) and experiencing the enactment of knowledge with interactive content (e.g., videos with semantically linked data) (Pratticò and Lamberti 2021). KUKA Xpert provides continuous revenue generation for KUKA through a subscription revenue model. By offering a case database instead of handling every customer issue individually (e.g., by hotline support), KUKA additionally achieves cost avoidance.

The second example we elaborate on is the MathWorks Community (MathWorks, Inc., 2022). We chose this particular example to illustrate the participatory knowledge sharing with and among customers, which is typical for the software industry but a contrast to the manufacturing industry. MathWorks develops the software MATLAB and Simulink and is a leading developer of mathematical computing software for engineers and scientists. MATLAB is used for data analysis, the development of algorithms and the creation of mathematical models. Based on this, Simulink is used for simulation, code generation, and verification of embedded systems. MathWorks offers a free forum-like community platform on their website where users of the software can interact with one another as well as with MathWorks support engineers to solve issues. Users can ask and answer questions, access and contribute code and models, or share and discuss relevant topics.

MD	Dimensions	Characteristics			
Value proposition	Offering	Knowledge application	Knowledge transfer	Embodied knowledge	
	Knowledge domain	Consulting	Maintenance	Training	Support
	Knowledge type	Implicit	Explicit		
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	Knowledge agent	Human	Artificial		
	Knowledge channel	Physical	Digital		
	Knowledge transfer	No transfer	Conversation	Information media	Experiencing
Value capture	Revenue stream	Cost avoidance	Revenue generation	Knowledge	Indirect
	Revenue model	Subscription	Transaction	Free	

Figure 5. MathWorks Community categorized according to the taxonomy.

Considering the taxonomy, the MathWorks community can be characterized as follows (Figure 5). Knowledge is transferred among the community on the website in the domains training (e.g., step-by-step descriptions on how to implement a certain code) and support (e.g., how to approach a certain problem). As the community is grounded in a digital platform and textual content, the offered knowledge type is considered explicit as knowledge of the community users are externalized (see Section 2.1), stored, and can be accessed by others. The threads and topics discussed in the community contain both basic and expert knowledge. As users and MathWorks employees contribute to the community, the knowledge source is considered internal and external, forming a community knowledge base. The knowledge base is accessed by users using a search function, thus the knowledge agent is considered human. The knowledge transfer within the community is executed exclusively digitally by written conversations among users and MathWorks employees and by information and media, e.g., linking an existing conversation as the solution of an issue. By hosting the community, MathWorks gains additional knowledge from their users and simultaneously supports them with a broad problem-solution database and fast response times (indirect revenue stream). The researchers assume that MathWorks can avoid costs as users help each other and interact in the freely accessible community.

4.3 Cross-case analysis

In the course of analyzing the 119 knowledge-intensive offerings from the software industry and the 66 offerings of the manufacturing industry, we were able to identify similarities and differences among both industries. Software firms naturally use digital channels and information systems to reach out to their customers. All software companies offer a knowledge base which their customers can access, often via their own website. Thereby, building up and operating an organizational knowledge base relies on a systematic knowledge management process. Explicit knowledge content is stored in the knowledge base and provided to customers, e.g., via information, documentation, examples, videos, problem-solution-fits etc., enabling customers to perform self-services regarding training or support. Software firms use the inherent capacities and capabilities of their customers to perform certain actions. This is equivalent to the logic of value co-creation (Vargo and Lusch, 2004) and integrated solutions (Valtakoski, 2017) as the provider delivers knowledge which the customer uses to execute activities. In addition, most software companies offer a community in which third-party users, e.g., customers, can interact and help each other. The users are often rewarded and, thus, earn reputation for solving issues and helping. This allows companies to additionally benefit from network and scale effects. These offerings are usually free of charge or integrated in bundles accounted for by subscriptions, e.g., a monthly fee for knowledge base access. For specific expert-level KIBS such as consulting, advanced support services, and expert training software companies employ specific specialists. Customers have to pay for these additional staff expenses. Consulting and training services are generally billed on a conventional transactional basis. However, PTC is the only company in the sample that started a learning subscription including a certain number of training courses for one of their software products. Advanced support and maintenance services tend to be bundled in subscriptions, e.g., Quest's "Premier support" which entails direct access to senior support engineers and a designated technical account manager.

Manufacturing companies, on the other hand, often still rely on manual and reactive service provision, especially in the context of support and maintenance. The dominant industry logic is still – and this can be particularly seen in the SMEs – that these services are billed on a transactional basis. Some of the large companies such as KUKA, Voith Hydro and Phoenix Contact offer additional service contracts. In these contracts, services such as remote support, preventive maintenance and 24/7-hotline are bundled and charged for via a subscription. Compared to software companies, manufacturers utilize digital channels less extensively to provide explicit knowledge content. Here, mostly digital manuals, machinery information and basic problem solutions are offered. Rather than providing explicit knowledge, manufacturing companies use digital channels to establish a direct connection to an expert and his or her implicit knowledge, for instance in the case of the remote support service of Heidelberg or Homag. Some manufacturing companies have established a knowledge base, but for internal usage. For example, Trumpf uses its knowledge base to equip their field service technicians with all necessary information to execute a customer issue most effective and efficiently. We did not discover any communities in the sample of manufacturing companies. All manufacturing companies offer consulting and training services. In almost all cases, these require personnel resources and are billed on a transactional basis. However, there is a recognizable trend in training. Four of the companies offer their customers a knowledge base and self-services for training purposes. As an example, the company KUKA offers a virtual-reality self-learning course. The key tendencies of how KIBS are designed in the two industrial contexts are summarized in Table 2.

Software	Manufacturing
Using IT-based knowledge bases for explicit knowledge transfer with customers.	Using IT-based knowledge bases rather for internal use of employees.
Integrate customers into the value creation process via self-services.	Execute knowledge-intensive services for their customers via personnel resources.
Offer forum-like communities where customers can interact with each other and with support personnel.	No communities, only bidirectional interaction between provider and customer.
Knowledge is given away for free or is charged for via a subscription model (often when personnel resources are additionally involved).	KIBS are mostly charged for on a transactional basis, except they are bundled in a service contract, then they are charged for in a subscription-like model.

Table 2. Differences regarding knowledge usage in the software and manufacturing industries.

5 Discussion and Conclusions

In this study, we built a taxonomy that systematizes how firms leverage knowledge in their service offerings and business models. Our taxonomy structures the fundamental constructs and relationships of knowledge in KIBS and serves as foundation for further sense-making and theory building (Kundisch et al., 2021). When building the taxonomy, we followed the iterative approaches of Nickerson et al. (2013) and Kundisch et al. (2021) and applied the business model dimensions (1) value proposition, (2) value creation, and (3) value capture as the conceptual lens. We conducted three iterations of taxonomy building, one theoretical-to-empirical and two empirical-to-conceptual iterations (Nickerson et al., 2013). For the empirical investigation, 185 KIBS from the software and manufacturing industries were examined. Additionally, we elaborated on the two solutions KUKA Xpert and MathWorks Community in more detail to demonstrate our taxonomy and conduct a cross-case analysis of the two industry contexts software and manufacturing. We found that the knowledge utilization strategies and application mechanisms differ among the two contexts.

This study provides three contributions for KIBS and servitization literature, which can be summarized as follows. First, the taxonomy serves as a classification scheme for KIBS by structuring their characteristics in eleven dimensions. We suggest to analyze the strategic use of knowledge considering a business model perspective. Taking such view helps to break free from the existing distinction between product, service and software components and might lead to an integrated view across domains, which has been called for in recent publications (Huikkola et al., 2021b). Further investigation of knowledge contributions and particularities of knowledge exchange and usage within different domains, e.g., in smart solutions might open up new research areas or can provide answers to open questions concerning the digital servitization transformation of manufacturers to KIBS firms. In this regard, the paradigm-shift from knowledge as a resource for KIBS application towards knowledge as a service and as a dedicated value proposition – enabled by digital technologies – might be an interesting field of further investigation.

Second, the taxonomy supports the generation of new KIBS offerings. Assuming that already knowing about other existing solutions can lead to a rethinking and further development of a company´s own business models and offerings (Loon et al., 2020), the taxonomy and the two demonstration cases might help to accelerate the transformation of manufacturing companies towards KIBS firms. Such transformation might be important for future competitive advantage. Revenues from KIBS are less dependent on resource consumption and therefore a promising path in the global challenge of reducing our footprint on earth (Bocken et al., 2014). KIBS like maintenance and repair, but also new ideas to reuse and share product resources, will become of utmost importance (Kirchherr et al., 2018) as these can create more value from fewer resources (Stahel, 2019). For the manufacturing industry in particular, the aim will be to extend the useful life of machines, to optimize their operation, and to increase their capacity utilization (Kirchherr et al., 2018). The accumulation of knowledge will be of great importance to innovate business models and to improve service operations in this direction (Ranta et al., 2021). In fact, research already requests "new ways to engage people in knowledge arenas in ways that emphasize collaboration and co-design of solutions, and lower barriers" (Cornell et al., 2013, p. 66). Although not in focus of this paper, the investigation of associated research streams like open innovation, knowledge sharing practices and collaborative knowledge creation might provide worthwhile perspectives. Studies on open innovation, defined "as a distributed innovation process based on purposively managed knowledge flows across organizational boundaries" (Chesbrough and Bogers, 2014, p. 24) have already pointed to the relevance of knowledge transfer between companies and how different actors can jointly create knowledge and value for a long time. However, related studies also highlight possible limitations and contextual factors, which are worth exploring further (Bigliardi et al., 2021).

Third, the cross-case analysis of the software and manufacturing industries elaborates on the different strategies and mechanisms on how to use knowledge for generating value. It is visible that the interplay of the providers' and customers' capacities and capabilities in integrated solutions is very relevant in this regard (Valtakoski, 2017). Our cases showed that software companies frequently share their knowledge free of charge and help their customers in their value creation processes by equipping them with the right knowledge to perform certain actions through self-services, e.g., troubleshooting in case of an issue. As software companies often possess comparatively large customer bases compared to manufacturing firms, giving away the knowledge for free and letting the customers execute activities based on this knowledge might be more efficient than handling every customer issue by an employee. Here, it is a debatable point whether such behavior, especially in the context of KIBS, also makes sense for manufacturing firms. Manufacturing firms, especially those in niche markets might in contrast come to a different decision, e.g., by protecting their knowledge for safeguarding competitive advantage. Even if it is said that manufacturing companies need to increasingly transform themselves into software companies (Leminen et al., 2020), we can assume that existing manufacturers' knowledge (i.e., product as well as service knowledge) might be worth protecting. That goes along with the results of Huikkola et al. (2021a, p. 46) who stresses that "manufacturers' existing capabilities, culture, and position in the markets" need to be considered within strategic decision making and specifically within the transformation towards a knowledge-intensive service provider. With respect to the concept of "inlearning" (Bouncken and Kraus, 2013), knowledge leakage is a risk that has to be considered (Tan et al., 2016). Companies must manage the effects of knowledge leakage in the long term while at the same time ensuring collaboration. Manufacturing companies should precisely consider which firms they partner with. These insights might serve as the foundation for further theory building, e.g., the derivation of patterns (Weking et al, 2020) regarding the integration of knowledge in services, solutions, and business models or a consideration of different inlearning strategies. Such further investigations might help servitization researchers answering the question what manufacturing firms should and should not learn from the software industry during the transformation towards service and solution providers.

We also see limitations of our work. Even though we considered 185 offerings, the total amount of case studies is limited. We only considered individual offerings from the providers and had to rely on publicly available information and sources, such as academic articles and websites. In some cases, we were only able to speculate on the offering's characteristics, e.g., if costs are actually reduced, or the motivations for a firm's strategic decisions. To overcome this limitation and triangulate our data, we consider conducting an interview study with the firms of our sample in the future. In particular, investigating the motivations for decisions regarding offerings and corresponding business models might yield relevant insights for firms transforming their business logic in the context of servitization. In addition, we focused on large corporations in the manufacturing and the software sector. Further studies could be carried out investigating pure industrial service providers or other providers of KIBS, e.g., universities or NGOs, to complement the taxonomy's dimensions and characteristics.

Finally, we see practitioners as the target user group for the taxonomy that might benefit from our findings. We expect the taxonomy to help especially manufacturing firms in analyzing existing and designing new KIBS. By adopting the business model dimensions as the taxonomy's meta-dimensions, the taxonomy is supposed to open up the design space of KIBS. The taxonomy's characteristics can be considered as design possibilities that might lead practitioners, e.g., service designers in manufacturing firms, to question their way of utilizing knowledge and envision new ones. For example, software firms share explicit knowledge stored in organizational knowledge bases with their customers and integrate them into the value creation process. By applying this approach (like with KUKA Xpert), manufacturing firms may achieve a similar decrease of costs and increase of customer satisfaction. Another example of sharing rather implicit knowledge of employees is solving issues at customer sites through remote support. By implementing an adequate physical and digital infrastructure including, e.g., augmented reality devices and remote support call software, manufacturing firms can prevent their employees from travelling to customer sites to solve issues customers could possibly handle on their own. Such KIBS would result in a more effective use of personnel support capacity from the provider perspective, a faster problem solving from the customer perspective, and less travel activities and CO_2 emission from an environmental perspective. We see a lot of potential in the utilization of knowledge in advanced service and solution offerings for manufacturing firms and call researchers and practitioners to use our taxonomy as a potentially useful design artifact (Kundisch et al., 2021) to leverage this potential.

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