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RESEARCH PAPER

Value co-creation practices in business-to-business platform ecosystems

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Abstract
Moving beyond value creation in individual companies, firms have integrated customers, partners, and stakeholders in a mutual value co-creation process. Examples are platforms such as Apple's App Store, where external developers use boundary resources provided on the platform to develop and share applications in an ecosystem. While value co-creation on business-to-consumer platforms is common practice, research on their business-to-business (B2B) counterparts is still sparse. The goal of this paper is to analyze how B2B platforms utilize value co-creation practices. We conduct a multiple case study in the context of emerging Internet of things (IoT) platforms highlighting that B2B platforms follow three standardized value co-creation practices. The platform encourages the supply side through the (1) integration of complementary assets, the demand-side through (2) ensuring platform readiness and connects both processes by (3) servitization through application enablement. We conclude by showing how platforms leverage different boundary resources in a process of standardization to develop a scalable infrastructure that explains how platforms enable value co-creation within their ecosystem.

Keywords Value co-creation · Digital platforms · Internet of things · Case study · Boundary resources · Standardization

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Introduction

The creation of economic value has shifted during the last decades from individual contributions by single firms to the integration of customer knowledge in product development (Edvardsson et al. 2012; Matthing et al. 2004) to the co-creation of value in complex service ecosystems (Skålén et al. 2015; Peppard and Rylander 2006; Prahalad and Ramaswamy 2004; Hippel and Katz 2002). For the latter, service platforms have emerged as a dominant model (Lusch and Nambisan 2015). Service platforms represent the center of an ecosystem of different actors and take advantage of network externalities by facilitating supply and demand (Lusch and Nambisan 2015; McIntyre and Srinivasan 2017; Hein et al. 2018c). The concept of ecosystems has changed the view from traditional inter-firm competition to a joint approach of coopetition – simultaneous competition and cooperation – between actors (Moore 1996; Adner 2006; Pereira et al. 2017).

Prominent examples of service platforms are application stores such as Apple's App Store and social media platforms such as Facebook, where complementors provide the majority of complementary products or services – applications in the case of the App Store and content in the case of Facebook. The complementors are part of the ecosystem that is continually enhancing the service platform and turning the value creation process into a joint value co-creation process (Parker et al. 2017). In this regard, owners of service platforms foster a loosely-coupled arms-length approach to integrating different

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parties into their ecosystem (Ghazawneh and Henfridsson 2013, 2015), while traditional companies use tight coupling in the form of strategic partnerships to co-create value (Orton and Weick 1990; Steensma and Corley 2000). This effect becomes apparent at the boundaries between a service platform and its ecosystem. The service platform provides boundary resources in the form of application programming interfaces (APIs) or software development kits (SDKs) to facilitate a scalable resource integration (Ghazawneh and Henfridsson 2013).

Research on value co-creation in service platforms mainly focuses on the business-to-consumer (B2C) market. Research objects are successful platforms such as Facebook (Lee et al. 2015), Uber (Teubner and Flath 2015), Airbnb (Zervas et al. 2017), or Apple's App Store (Eaton et al. 2015). In contrast, research on emerging business-to-business (B2B) platforms is still sparse (Sarker et al. 2012; Förderer et al. 2018). However, there are grounds to consider that value co-creation practices between B2C and B2B platforms differ. First, the service ecosystem of B2B platforms is more complex compared to their B2C counterpart. Internet of things (IoT) platforms, as an example in the B2B market, cannot solely rely on third-party developers to ensure value-adding services. The platform also needs to encourage the participation of sensor manufacturers, software and application companies, and consumers subject to different, inhomogeneous environments (e.g., machines, processes). Second, users are not private individuals but legal organizations, which use the platform for business-critical processes. Third, B2B services are more complex compared to B2C services. In the case of IoT platforms, the platform owner must provide device management, compatibility with sensors and machines, and communication protocols to the demand of industrial customers.

Accordingly, our research objective is to understand how B2B service platforms foster value co-creation. From a theoretical perspective, we draw on the service-oriented framework of Lusch and Nambisan (2015) to describe the actor-to-actor (A2A) ecosystem, and the value co-creation process connecting those actors. Based on the value co-creation practice, we adhere to the principle of boundary objects coined by Star (2010) to elaborate on the platform boundary resources (Ghazawneh and Henfridsson 2010, 2013) that enable the value co-creation practice. Methodically, we follow a multiple case study subject to three B2B service platforms in the field of IoT (Yin 2014). We show that IoT platforms transition toward an application enablement platform (AEP) through the standardization of three value co-creation practices: platform readiness on the user side, the integration of complementary assets on the demand side, and the servitization through application enablement as a core value-adding service. In addition, we illustrate that a potential consequence of those standardized practices are residual co-creation mechanisms.

Theoretical foundations

We combine two theoretical perspectives to describe value co-creation practices in B2B platforms. The service-dominant (S-D) logic elaborates on how platforms co-create value in A2A ecosystems (Lusch and Nambisan 2015). The theory of boundary objects (Star 2010) and boundary resources in the context of platforms (Ghazawneh and Henfridsson 2010, 2013) serves as a dynamic concept to illustrate how B2B platforms facilitate value co-creation with their ecosystem.

Service-dominant logic

The process of value creation has shifted from a goods-dominant (G-D) logic with a focus on tangible goods that are created in the confines of an organization to a joint process where value is co-created in an A2A ecosystem based on an S-D logic (Chesbrough 2006; Vargo et al. 2008; Vargo and Lusch 2004). The S-D logic focuses on the exchange of services during which one actor uses a set of skills and capabilities to benefit another actor. Lusch and Nambisan (2015) developed a framework along the three dimensions service ecosystem, service platform, and value co-creation to explain the nature of service innovation. The framework is well suited to describe value co-creation practices in B2B platforms, as each dimension addresses different issues and concepts related to platforms.

A service ecosystem is a community of interacting actors organized in an A2A network (Orlikowski 1992). Actors in the A2A network co-evolve their skills and roles in mutual dependency striving for effectiveness (Moore 1993; Adner 2006). We adopt the definition of service ecosystems proposed by Vargo and Lusch (2011) as a self-adjusted, self-contained system of regularly loosely coupled economic and social actors. A service ecosystem connects different actors through services that foster mutual value creation and a shared institutional logic. However, there are three issues that scholars and practitioners need to consider (Lusch and Nambisan 2015). First, the ecosystem needs to provide structural flexibility and structural integrity. Structural flexibility refers to how easily actors can collaborate within an ecosystem; it governs business agility (Tilson et al. 2010). Structural integrity describes the relationship between the actors within an A2A network and their degree of coupling, serving as an indicator for ecosystem engagement (Lewicki and Brinsfield 2009). Second, service ecosystems need to offer a shared worldview to bridge the cognitive distance between involved actors (Hendriks-Jansen 1996; Weick 1995). A shared worldview in the form of standards or institutional logic ensures that actors mutually interpret the integration of resources and that they align more quickly on resource exchange (Lusch and Nambisan 2015). Third, the service ecosystem needs to provide an architecture of participation. This architecture facilitates the interaction between actors by applying transparent rules and providing transparency with regard to the actor's contribution.

A service platform liquefies resources and enhances resource density to facilitate an efficient and effective exchange in a service ecosystem. We adopt the definition of Lusch and Nambisan (2015) for a service platform as a modular structure that combines tangible and intangible resources or components and coordinates the interaction of resources and actors. Resource liquefaction refers to the decoupling of information from a physical representation allowing it to be shared in turn fostering generativity (Normann 2001; Tilson et al. 2010). Resource density describes the speed with which resources can be mobilized for an actor (Normann 2001; Lusch et al. 2010). A layered-modular architecture facilitates either functional designs leading to different core value propositions or cross-design hierarchies creating new value propositions (Baldwin and Clark 2000). Such an architecture allows for the scalable coordination of service exchanges to generate more opportunities for value co-creation and service innovation. The modular architecture engenders the need for platform governance. The associated rules define the way interactions in the A2A network are governed, ranging from an open policy to restrictive rules (Lusch and Nambisan 2015; Benlian et al. 2015; Hein et al. 2016; Schreieck et al. 2018).

The co-creation of value describes the process of value creation between actors within a service ecosystem on a service platform. From the S-D-logic, actors can take different roles in the process of value creation. S-D logic differentiates between the service offerer and the service beneficiaries. The beneficiaries can take the roles of an ideator, designer, and intermediary (Lusch and Nambisan 2015). The ideator distributes knowledge about needs in a specific context and integrates it into new market offerings. The designer mixes and matches resources or knowledge to develop new services. The intermediary distributes and shares knowledge across multiple service ecosystems. Each role integrates existing resources and knowledge with peers in the ecosystem, resulting in new service opportunities. To optimize opportunities for value co-creation, the platform needs to establish transparency about who ecosystem actors are, what and whom they know, and what they can do (Schreieck and Wiesche 2017). There are three issues that scholars and practitioners should address (Lusch and Nambisan 2015). First, the platform needs to facilitate interaction in a service ecosystem. The more actors interact, the more they learn from one another, which determines what they can do as actors. Second, the institutional logic such as organizational structures, roles, and processes needs to be aligned with new value co-creation services. Third, clarifying and communicating the platform's rules and protocol is essential to resolving intellectual-property issues.

Boundary resources

Accounting for the issues raised by Lusch and Nambisan (2015), we introduce the principle of boundary resources to illustrate how a service platform facilitates the co-creation process in a service ecosystem and how boundary resources can help to resolve those issues. Star and Griesemer (1989) proposed the notion of boundary objects in the social sciences to explain how different groups interact in the absence of consensus.

A crucial step to make information compatible across divergent groups is standardization. The process of standardization provides a common ground between different groups by introducing a 'lingua franca.' In this regards, boundary objects help to provide a strong structure for individual needs and a weak structure to maintain a common identity across different groups (Star and Griesemer 1989). Table 1 illustrates a non-exhaustive list of four types of boundary objects. Each type provides a shared structure through interpretive flexibility, work processes, and movement between ill-, and well-structured representations.

Interpretive flexibility describes differences in the use and interpretation of objects. An example could be a map with which one group looks for camping sites, while the other group looks for hiking routes. The boundary object provides structural flexibility as every group can adapt it to their specific context. In addition, the map is robust enough for both groups to be able to exchange information about different locations. This characteristic fosters structural integrity, as specific knowledge can be shared between groups (Star and Griesemer 1989).

Work processes relate to the form in which data is organized (e.g., through routes, locations, GPS data). In a repository, for example, the archivist extracts metadata from a book and puts it into a standardized system or library. The archivist adheres to a standardized method or protocol by first liquefying information from physical resources (e.g., books) and then mobilizing the records (resource density) to a variety of users who can borrow or use it (Star and Griesemer 1989).

Last, there is the transition from ill- to well-structured representations. This characteristic illustrates that boundary objects are not a static concept but exist simultaneously in an abstract form across a variety of disciplines (ill-structured), while also being useful in a specific context for a distinct group (well-structured) (Star 2010). This characteristic is crucial when describing the origin and development of boundary objects.

Star (2010) emphasizes the development of boundary objects through the dynamic process of standardization (see Fig. 1). In an analogy to a map, people try to control the tacking back-and-forth between abstract and specific representations. An example is to standardize coordinates, databases, and different representations of maps in a geographical

Table 1 Types of boundary objects (according to Star and Griesemer (1989))

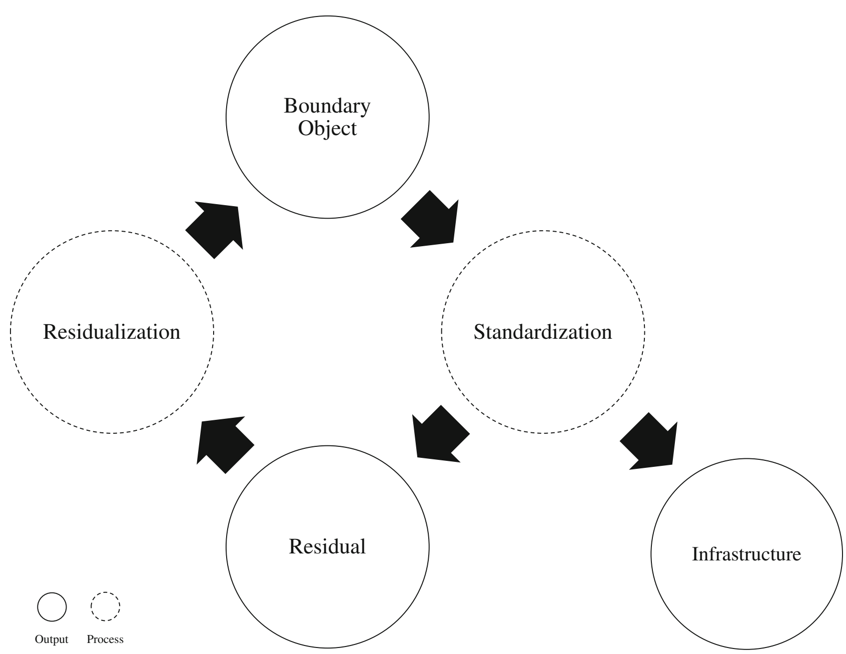
Type	Description	Example
Repositories	Repositories are specific arrangements of objects that are indexed in a standardized way. Objects are arranged as modules and can be used according to different purposes	Library, archive
Ideal type	Ideal types arise from different degrees of abstraction. They serve as a means of cooperating between different parties through the deletion of local contingencies from a real-world object	Species, atlas
Coincident boundaries	Coincidental boundaries share the same boundaries but are subject to different internal contents. An example is a map with which each party can work toward an individual goal but that also allows for collaboration and communication	Maps
Standardized form	Standardized forms are used to gather information that is compatible across divergent worlds. A benefit is the complexity reduction as local uncertainties are deleted	Standardized form, survey

information system (GIS). The former boundary object (map) becomes an infrastructure (GIS), which resolves the tension between local and global perspectives (Star and Ruhleder 1996). However, standardization tends to throw off residual categories, as the infrastructure cannot account for all possible interaction scenarios. In the process of residualization, new user groups inhibit the residual and begin to start a new boundary object. Out of this development, a cycle is born (Star 2010).

Platform research adopted the concept of boundary objects and coined it boundary resources to explain the arms-length relationship between the platform and its ecosystem through software development kits (SDKs) or application programming interfaces (APIs). Boundary resources use the innovation network literature to describe how B2C platforms govern their ecosystem (Ghazawneh and Henfridsson 2010, 2013) or how boundary resources emerge and evolve based on the interaction between different actors through the process of distributed tuning (Eaton et al. 2015). The boundary resources can enhance the scope and diversity of a platform like in the introduction of ARKit in the iOS ecosystem in the process of resourcing. Furthermore, the platform owner can increase the control over services in the process of securing (Ghazawneh and Henfridsson 2013). More recent research emphasizes the design of knowledge boundaries in B2B platforms (Förderer et al. 2018). While especially the latter study addresses the point of how a platform can design knowledge boundaries, it remains unclear how B2B platforms co-create value with their ecosystem. Thus, we adhere to the S-D logic and the three building blocks of a service platform, which connect a service ecosystem through value co-creation (Lusch and Nambisan 2015). We combine the three building blocks with the dynamic concept of boundary objects (Star 2010) to describe how IoT platforms transitioned toward an application enablement platform (AEP) by standardizing value co-creation practices.

Table 2 summarizes how boundary objects (Star and Griesemer 1989; Star 2010) and boundary resources in the context of platforms (Ghazawneh and Henfridsson 2010, 2013; Eaton et al. 2015) can account for issues raised in the S-D framework (Lusch and Nambisan 2015) to describe value co-creation practices in service platforms.

Fig. 1 Relationships between standards and residuals in the dynamic concept of boundary objects (Star 2010; Steger et al. 2018)



Research design

For the research design, we follow a multiple case research strategy. The method is particularly suitable, as it captures and describes the complexity of novel phenomena (Yin 2014; Stake 1995). The multiple case study covers three B2B IoT platforms that illustrate boundaries, features, and limitations, by putting the S-D framework and the concept of boundary objects into the context of the qualitative interviews, respective environments, and firms (Stake 1995; Merriam 1988). A cross-case analysis allows us to draw more robust conclusions on value co-creation practices by contrasting and replicating our findings from individual cases (Yin 2014).

Benbasat et al. (1987) provide guidance on whether the usage of a case study is appropriate. First, it is important to observe the utilization and development of value co-creating practices in B2B platforms in a context-dependent environment. Thus, we derive the data for the case studies through on-site interviews with the platform owners, as ecosystem collaborations cannot be observed from an external perspective (Eisenhardt and Graebner 2007). Second, the tremendous success of platform businesses such as Facebook and Uber show the significance and relevance of the research topic. While there are already established markets leaders in the field of B2C platforms, B2B and especially IoT platforms are not yet settled (Hein et al. 2018a). Thus, there is a clear link to the contemporary event of emerging B2B platforms. Additionally, neither control nor manipulation of the subject or event took place, as the case study describes the phenomenon in the view of a neutral observer. Lastly, the phenomenon enjoys a theoretical base building on value co-creation literature but focusing on B2B platforms that have received little attention so far. Furthermore, the value co-creation practices of B2B platforms are grounded in a real situation described by case studies (Siggelkow 2007).

We sampled B2B platforms in the IoT context with an already established ecosystem of actors. We chose IoT platforms, as they are an emergent phenomenon co-creating value with a variety of ecosystem partners (Shim et al. 2017). We gathered the data for each case through semi-structured interviews on the site of three IoT B2B platform owners. We focused on employees that are directly involved with ecosystem partners, as those could elaborate on the particular co-creation practices. We chose semi-structured interviews as they provide room for improvisation and exploration of the underlying phenomenon.

The interviews included questions subject to the actors in the service ecosystem, the boundary resources provided by the platform, and the process of value co-creation (Myers and Newman 2007). In the first part of the questionnaire, our questions focused on what actors contribute to the value co-creation process in the platform ecosystem. According to the

Table 2 Summary of S-D specific issues on value co-creation and how boundary resources cccount for them (own illustration based on concepts of Ghazawneh and Henfridsson (2013) and Lusch and Nambisan (2015))

S-D Dimension	S-D Issue	Boundary resources
Service ecosystem	Structural flexibility/integrity	Provide interpretive flexibility among groups. SDKs can provide a set of tools and boilerplate codes that can be used by actors to create plug & play solutions on the platform
	Shared worldview	Provide a weak structure connecting groups with a different institutional logic
	Architecture of participation	Standardized infrastructures provide an architecture of participation. Boundary resources can provide an architecture of participation in service ecosystems, which in turn influences the evolution of boundary resources through distributed tuning
Service platform	Resource density	Work processes (standardized methods) and digital interfaces such as APIs provide a process for liquefying information from physical sources. In the process of resourcing, the scope of the platform can then be enhanced via the liquified information
	Define rules of exchange	Work processes (standardized methods) provide a 'lingua franca' among ecosystem actors. Digital interfaces such as APIs provide a defined structure through payloads and secure interfaces in an ecosystem
Value co-creation	Facilitate interaction in ecosystem	Standardized infrastructures resolve the tension between local and global understanding, thus facilitating interactions. Digital interfaces and SDKs facilitate interactions in an ecosystem
	Adapt internal processes	Well- and ill-structured characteristic of boundary resources provides interpretive flexibility to account for internal processes
	Transparency on resource integration	Work processes (standardized methods) ensure transparency over (possible) ways on how to integrate resources. Digital interfaces such as APIs secure a clearly defined data structure

interviewees, those actors range from software developers to sensor manufacturers to consulting companies to business customers. Next, we asked specific questions on how the platform owner integrates those actors in the ecosystem. Typical examples are boundary resources such as APIs, SDKs, web interfaces, and boundary spanning activities like on-site collaborations. Last, we focused on the process of value co-creation. An example is how the different actors integrate sensors or software into the platform. Furthermore, we considered the complexity aspects on the side of the platform owner by asking open questions addressing their position on value co-creation.

In total, we conducted 11 face-to-face interviews (see Table 3) from November 2016 to February 2017. We recorded, transcribed, anonymized and sent back the transcriptions to the interviewees to provide additional comments. The final transcripts were then used for data analysis. The authors followed the guidelines of flexibility, non-direction, specificity and range during the interviews to increase the received value (Flick 2009) and paid attention to neutrality and a non-judgmental form of listening (Patton 1990; Walsham 1995).

As for the data analysis, we followed the coding mechanisms proposed by Strauss and Corbin (1996). We used the 11 interviews as data slices starting the process of open coding, where we coded the concepts and codes word-by-word. Examples are specific actors such as sensor manufacturing companies, types of interaction such as strategic partnerships with industry leaders or boundary resources through APIs. After that, we conducted axial coding to describe the relationships between codes. The results were constantly compared with already coded slices to derive similarities between actors, boundary resources, and value co-creation interactions. We documented changes in relationships via the process of memoing. Finally, we conducted a selective coding based on the theoretical constructs of the S-D framework (Lusch and Nambisan 2015) and dynamic process of boundary objects (Star 2010) to derive core categories that are robust along all three cases describing value co-creation practices (Urquhart 2012).

Results

The interviews indicate that B2B IoT platforms struggled with three issues when it comes to fostering value co-creation in their ecosystem. First, the ownership of products and services was unclear. This problem states that ownership rights for data, applications, and services are unclear from the partner's point of view, as described by the *Strategic Innovation Manger* of *Alpha*. Second, B2B customers account for special requirements, like the need for stable services, compliance with security, regulations, or high-quality standards. A *Developer* from *Beta* described, "*He [the customer] asked whether the solution is in conformance with the data protection laws for health insurance firms. He showed me how strict the regulations are.*" Third, B2B customers have an inhomogeneous and highly specialized landscape of machines, processes, and systems. The *Strategic Innovation Manager* of *Alpha* describes the fact that, "*There might be thousands of machines. Machines, sensors, and thousands of possible use-cases on top.*" Thus, developers need special insight into the customer's department, machines, and processes to work on IoT solutions.

To account for those problems, the platform owners introduced an application enablement platform (AEP). The AEP enables scalable resource integration by combining three value co-creation practices that foster interaction in its ecosystem. In each practice, there are at least two distinct actors, each

Table 3 Firms and interviewees (own illustration)

Organization (anonymized)	Description	Duration (mm:ss)	Role
Alpha	Alpha is a leading business-to-business IoT platform. They provide industry solutions through strategic partnerships and the combination of open services on their platform. The platform targets clients in the enterprise and SME sector.	53:20 66:25 54:02 40:40	Innovation Manager Business Development Head of Sales Director Machine-to-Machine Communication
Beta	Beta is one of the leading Cloud-Platform providers. Through acquisitions and contribution in Open Source software, Beta has established a scalable cloud architecture. This architecture is a prerequisite and the basis of the IoT platform. The IoT platform on top of this architecture provides several industry-specific solutions and building blocks in the area of IoT.	53:44 55:28 49:34 63:16 45:00 61:10	Knowledge Manager Consultant Sales Platform Architect Technical Consultant Platform Architect Application Developer
Gamma	Gamma is an IoT platform start-up. The firm focuses on OEMs in the automotive industry. They use technical and industry expertise to provide solutions for specific use-cases on their platform. Due to the company size, the number of interviewees was limited to the CEO.	86:22	Chief Executive Officer

subject to their own institutional logic and connected through boundary resources (see Table 4).

Integration of complementary assets

The co-creation practice *integration of complementary assets* describes relationships that target the supply-side of an IoT platform. Instead of creating each service, sensor, and application by themselves, platform owners aim to provide an infrastructure that enables partners to self-integrate their resources. Partners want their resources to be on the platform to access the installed base of users in the platform ecosystem and thus obtain market access. Therefore, the platform provides boundary resources like web interfaces, APIs, SDKs, and documentations to enable partners to integrate and develop complementary assets. In addition, the platform adheres to boundary spanning activities to align with industry partners to implement vertical solutions.

One role of a partner is a device manufacturer providing the hardware and integrating it into the platform to comply with the standards, applications, and services provided by the platform owner. For the platform, each new device integrated into the platform is beneficial for the installed base of customers. In turn, each new device increases the perceived value of customers to join the platform. This beneficial relationship between supply and demand underpins the positive cross-side network effects. The *Head of Sales* of *Alpha* illustrates this effect:

> "*And then we have an ecosystem of hardware partners. [...] The primary motive of them [Hardware Partners] is to be integrated. In the end, it is a win-win situation. They are platform-ready [Platform services can be used by customers] and they can provide their solution to all of our clients, and our clients can use the convenient plug & play hardware.*" *(Head of Sales, Alpha)*

Besides hardware, services can be integrated into the platform. For example, external partners can offer a text-to-speech service on the platform. The integration of additional services and devices makes sure that the IoT device and application landscape becomes a modular part of the platform ecosystem. The resulting heterogeneity of service offerings in the ecosystems tackle the variety of the customers' landscapes, and provides an easy-to-use toolkit solution for them. The *Head of Business Development* of *Alpha* and several interviewees from *Beta* indicate that their clients utilize third-party applications and services that were integrated by partners into the platform. An example is the offering of text-to-speech services, which are integrated through standardized protocols and services to fit the toolbox solution.

The interviews indicate that not all practices apply to this standardized self-integration. The *Director of Machine-to-Machine Communication* of *Alpha* emphasizes that applications developed by customers are often too specific to be of any value for other customers. In those cases, the platform owner evaluates the applicability and value-add for other

Table 4 Value co-creating practices within application enablement platforms (own illustrationn.)

	Integration of complementary assets (demand-side)	Ensuring platform readiness (supply-side)	Servitization through application enablement (core practice)
Actors	Platform owner, partner, and customer	Customer, partner, and platform owner	Platform owner and customer
Institutional logic toward value co-creation	*Platform owner* wants to incorporate sensors, services, applications to increase the value of the platform	*Customer* wants to join the platform to benefit from services such as device management or data analytics	*Platform owner* wants to increase the profit by providing PaaS services and infrastructure including plug & play applications
	Partner wants to sell sensors, services, applications to an installed-base provided by the platform	*Platform owner* wants customers to join the platform to increase profits	*Customer* wants to develop toolkit solutions by providing department and end-customer insights/data
	Customer develops a specific application that could prove useful for other customers	*Partner* in form of consultancy firms want to ensure platform readiness for customers to increase profits	
Boundary resources	Web interface for self-service integration; APIs, SDKs, documentation for unique applications; boundary spanning activities like on-site offices for strategic partnerships	Documentation and how-to guides; consulting as boundary spanning activity	IoT platform that enables customers to develop applications
Example	Development of industry solutions with partners like manufacturing or automotive. Integration of new devices and services (e.g., text-to-speech)	Enabling customers to comply with platform standards like JSON and MQTT. Showing potential of platform utilization	Change from physical to remote maintenance to predictive maintenance

customers and abstracts the application to match a broader group of users.

Last, the *Knowledge Manager* of *Beta* points out that the platform is in close collaboration with industry leaders. Together they combine industry-specific knowledge with technological IoT expertise to create industry-specific vertical solutions. Those packages range from industries such as manufacturing to insurance to energy.

The seamless integration of partners into the standardized and modularized platform architecture further shows that customers need to adapt their environment to comply with the services, which leads to the next value co-creation practice within an AEP.

Ensuring platform readiness

The second value co-creation practice targets the demand-side by *ensuring customers' platform readiness*. The standardized value co-creation service follows a self-service integration logic. The platform provides documentations and how-to guides to enable customers to join the platform.

However, due to the complexity of each customer's processes, machines, and sensors involved, there are consultancy companies bridging the gap between the platform and customers. Customers provide insights into their products, services, and data, while the consulting company acts as a boundary spanner offering technical, IT, and strategic expertise. Together, they adjust the technical landscape to comply with the standardized platform infrastructure. Those collaborations show the potential of new, IoT-enabled solutions when joining the platform. The *Technical Solutions Leader* of *Beta* emphasized this point:

> "*[…] and if they [customers] now want to optimize their products or processes, they cannot do so due to the lack of software developers. If he [client] wants a solution from sensors to analytics to insights, he needs a competent partner. A typical example is our partner [IT consulting firm]. They enable the customer to join and use the platform.*" *(Technical Solutions Leader, Beta)*

The example shows that the practice of ensuring platform readiness is a co-creation process between external platform partners such as consulting firms and the client who is in need of technical change to comply with platform standards or wants to implement IoT applications.

Servitization through application enablement

The practice of *servitization through application enablement* describes the core co-creation practice between the platform owner and the customer. Both, the integration of complementary assets (supply) and the assurance of platform readiness (demand) are pre-conditions for this facilitating co-creation practice. The platform owner provides a standardized and modularized platform-as-a-service (PaaS) infrastructure including all the assets from the ecosystem. Customers use the PaaS infrastructure as a boundary resource, which they adopt to their institutional logic including machines, departments, and processes.

This practice enables customers to develop their own apps on a public, dedicated, or on-premises PaaS infrastructure, in addition to the plug & play applications that are offered on the platform. The offering of these three different deployment categories provides a solution for the ownership problem and considers external factors such as compliance with data privacy laws. With the option of a dedicated infrastructure, the customer can decide where the data center is located. *The Knowledge Manager* of *Beta* points out that it is important to have the data stored in countries with strict data protection laws. Firms also may run the system via an on-premises solution on their hardware.

Besides the technical infrastructure, the value co-creation practice also enables customers to build their applications with a toolkit solution. The *Head of Sales* of *Alpha* explains:

> "*We provide them with 70 - 80% of the solution - stable solutions in the field of mobile communication and device management […] we deliver 80% of the solution they need. The client can concentrate on their core business and their sensor data. This enables us to do what we do.*" *(Head of Sales, Alpha)*

Those toolbox services enable customers to create solutions through the combination of existing applications. A good example of a specific solution resulting from a toolkit application is provided by *Alpha*. Here, the *Head of Business Development* explains that a customer used a package for GPS tracking to build an application that helps their end-users in the maritime industry to track cargo ships. They used the non-specific tracking services to build the application. They added geo fences via drag & drop to be notified whenever ships leave or enter a harbor. The platform owner provided the customer with a toolkit of applications to build their own, value co-created solutions for unique scenarios. This example illustrates that new, differentiating activities (well-structured) result from the combination of abstract non-differentiating (ill-structured activities) offered by the platform owner. The *Strategic Innovation Manager* of *Alpha* describes this phenomenon as "*[...] a clever bundling of services may lead to innovations that did not exist before.*" A *Technical Consultant* of *Beta* concludes:

> "*[...] you always find something you can take advantage of. You do not need to invent everything [service/application] by yourself, which is a gain in time or inspires you to*

> *come up with new ideas. When you join our platform, you will find many services that you can combine, and you come up with new ideas as to how to develop a new business model."* *(Technical Consultant, Alpha)*

Overall, the core value co-creation practice of an AEP facilitates the supply in the form of a toolbox solution of preconfigured applications, sensors, and services, and a demand side of customers that are ready to use those services. The modularity and standardization enable servitization – "*[…] so [that] our client can just use the service.*", as the *Head of Sales* of *Alpha* concludes.

Discussion

We discuss the findings along the three main value co-creation practices targeting the supply-side through the integration of complementary assets, the demand-side in the form of ensuring platform readiness, and the core value-adding service as servitization through application enablement. For each value co-creation practice, we identify value co-creation mechanisms that result from standardization and residualization of the co-creation practices (Star 2010).

From a theoretical perspective, we draw on the S-D framework (Lusch and Nambisan 2015) in combination with the dynamic concept of boundary objects (Star and Griesemer 1989; Star 2010) and boundary resources in the context of platforms (Ghazawneh and Henfridsson 2013) to describe how the platform implemented each value co-creation practice.

Supply-side value co-creation practice

The supply-side value co-creation practice of integrating complementary assets involves a supplying entity and an integrating entity. Both institutional logics are connected through boundary resources. Figure 2 shows the main value co-creation practice (gray box) and three instantiations or mechanisms in the form of self-service integration, integration through abstraction, and strategic integration.

Self-service integration describes the standardized process in which the partner uses the platform boundary resources in the form of documentation, how-to guides, APIs, and SDKs to integrate its products or services on the platform. The platform acts as an infrastructure that is both abstract to apply to a wide range of actors such as device manufacturers, service providers, or application developers, and specific to be applied to the institutional logic for each of the integration partners. The partners use APIs and SDKs as a standardized form to integrate products or services and to make them comply with platform standards. The standardized form provides a shared (data) format for integrating products or services (Star and Griesemer 1989). Also, partners use boundary resources such as documentations and how-to guides as coincident boundaries similar to a map to create new boundary resources like documentation, boilerplate code, and further information so that other users on the platform can use the integrated products or services. The newly created boundary resources, like boilerplate code, are vague, thus providing an ill abstraction to bridge the gap between the product or service and the users on the platform who are going to apply it to a variety of use cases. There are parallels to other industries (Weking et al. 2018a; Weking et al. 2018c). However, the IoT platform needs to bridge a wider gap when it comes to interpretive flexibility and the adaption of internal processes on the customer side compared to other platforms. While complementors in app stores only need to provide information on how to use the app, IoT complementors also need to provide the code on how to embed their product or service in a wide range of customer landscapes. The mechanism of self-service integration scales to the end of the platform, as the platform only provides the standardized work process and the partner collaborates in a loosely coupled relationship toward this goal.

Integration through abstraction is a residual value co-creation mechanism where the platform owner uses specific applications provided by customers to aggregate them toward broad applicability among users. Compared to the standardized mechanism of self-service integration, the integration through abstraction results from customers who want to monetize internally developed applications. First, customers use boundary resources such as APIs and SDKs as standardized forms to develop specific applications as ideal types for their own use. Customers then would like to monetize those applications on the platform. However, the application of the customer is too specific to the customer's situation to be of any use for other customers. Then, the platform owner steps in and aggregates the specific application as a new boundary resource in the form of an ideal type (Star and Griesemer 1989). Both parties work as a designer, the customer providing the idea in the form of a specific application, and the platform owner providing the standardized abstraction that can be offered to a variety of platform users. While the relationship is loosely structured as most of the interaction is done via standardized boundary resources, the relationship is not scalable, as both parties act as designers. There are similar value co-creation mechanisms as illustrated by the LEGO platform, in which customers can propose LEGO-specific boxes that are then produced and sold by the platform (Schlagwein and Bjørn-Andersen 2014). When comparing the LEGO with the IoT mechanism, the process on LEGO is already standardized and scalable for the platform, while the residual mechanism on the IoT platform still demands the effort of both parties to integrate the application.

Strategic integration is the second residual process and subject to the collaboration between the platform and a strategic partner. Both parties aim to develop a vertical solution that provides end-to-end support for industries such as automotive

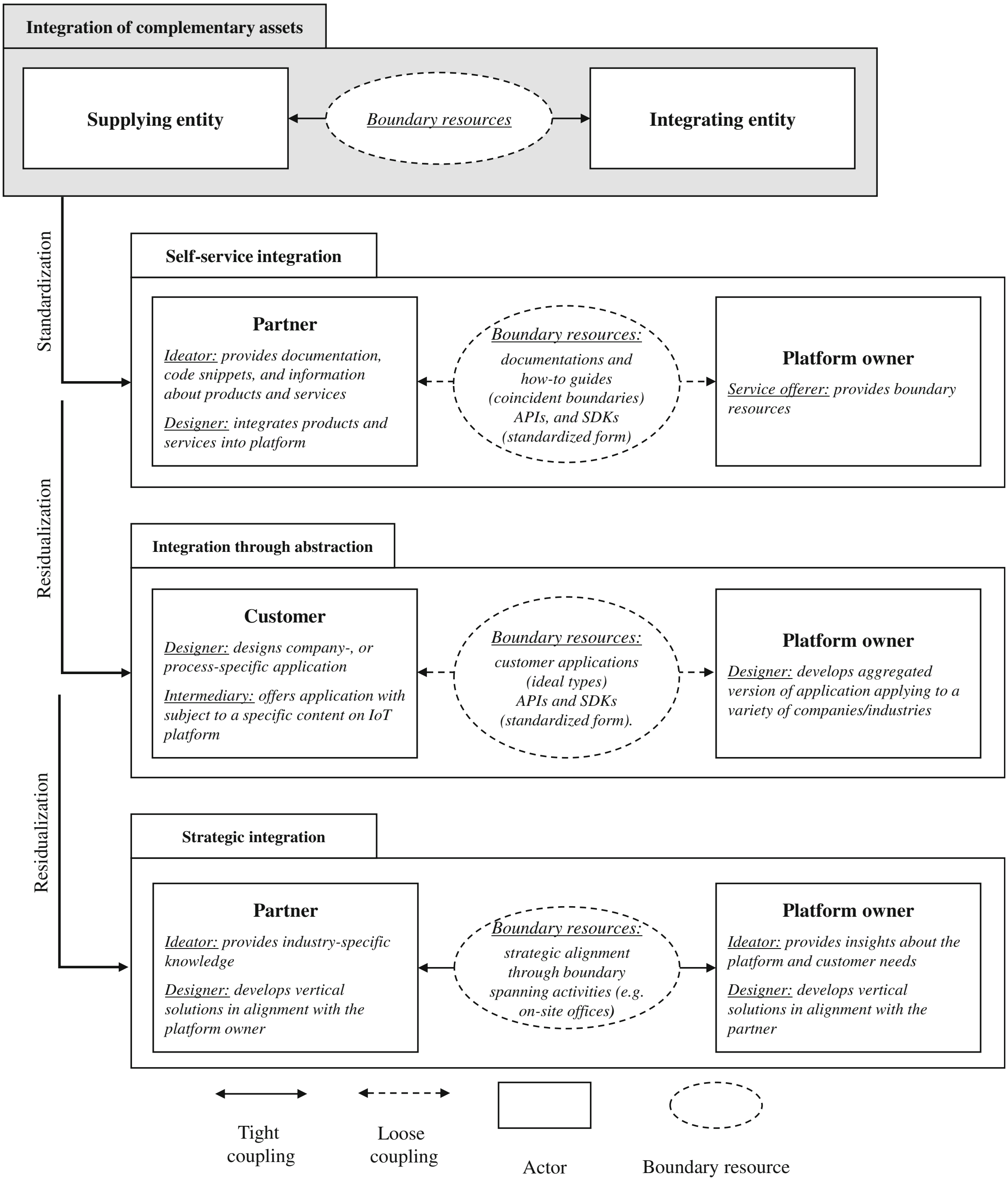


Fig. 2 Supply-side value co-creation practice of integrating complementary assets (own illustration)

or equipment manufacturing (Schreieck et al. 2017). Those industry solutions cover the full lifecycle from design, to supply, to production, to operations, and to maintenance. The scope of vertical solutions demonstrates the complexity of the development task and the mutual understanding needed of both parties. According to the interviews, the IoT platforms foster this strategic alignment through boundary spanning activities in the form of on-site offices, where personnel of both parties work together. There are various other examples of strategic partnerships that are used to increase the value of a platform such as the collaboration of Apple and IBM to tackle business applications. Due to the tight coupling partnership, the value co-creation mechanism scales on neither side (Hein et al. 2018b).

Demand-side value co-creation practice

The demand-side value co-creation practice of ensuring platform readiness involves a demanding and an enabling entity. Both institutional logics are connected through boundary resources. Figure 3 shows the main value co-creation practice (gray box) and two instantiations or mechanisms in the form of self-service readiness and supported readiness.

Self-service readiness describes the standardized value co-creation mechanism of a customer that uses platform resources to comply with platform standards. In this scenario, the platform provides transparency of a working process on how to comply with platform standards by providing boundary resources as co-incident boundaries such as documentation and how-to guides (Star and Griesemer 1989). Customers act as service beneficiaries by applying those boundary resources according to their institutional logic (e.g., machines, sensors, and uses cases) to update their infrastructure to comply with platform standards. The platform acts as an infrastructure, in which customers can opt in a loosely coupled relation to the platform. Thus, the co-creation mechanisms scale to the end of the platform owner, as the customers themselves need to ensure platform readiness. An example in the IoT context are customers who joins the platform, read the documentation and how-to guides, and set-up their infrastructure to support communication protocols such as MQTT. Similar self-service co-creation mechanisms can be found across a variety of industries. Companies usually provide boundary resources like manuals (e.g., app-development guidelines or assembly instructions) with the aim to create transparency over a working process through instructions on how to use and assemble products or services.

Supported readiness is a residual that results from the standardized mechanism of self-service readiness. The value co-creation mechanism mitigates relationships between customers and the platform that are not able to follow the self-service readiness mechanism. A reason is the low structural flexibility, where customers lack the capabilities to use available boundary resources to comply with platform standards. To mitigate this issue, customers collaborate with consultancies that act as boundary spanners in a tightly coupled relationship. The customer provides insights about machines, sensors, and potential use-cases, while the consultancy uses its knowledge about platform standards and feasible use-cases. As both parties need to establish a mutual understanding of each other's institutional logic, they need to work closely

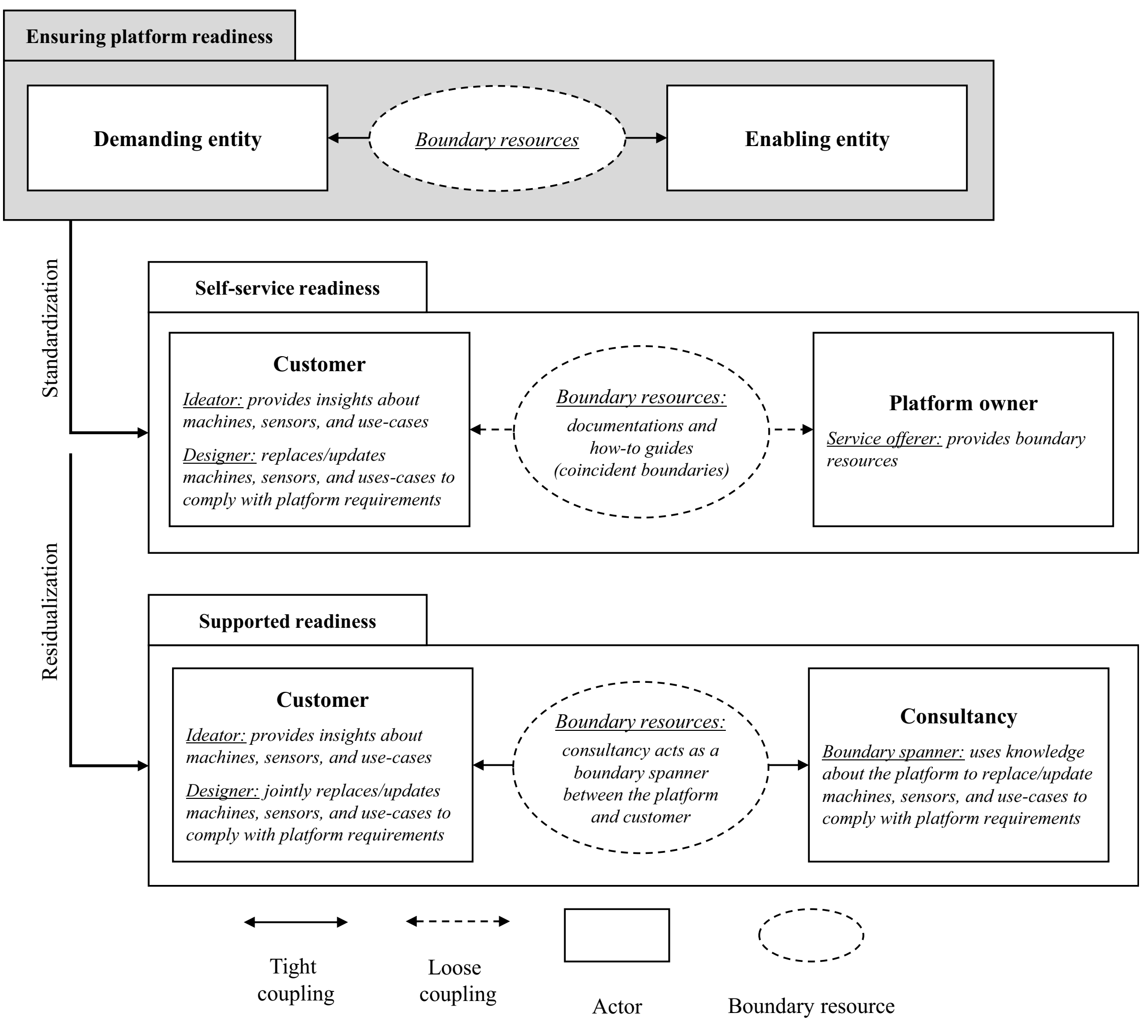


Fig. 3 Demand-side value co-creation practice of ensuring platform readiness (own illustration)

toward the common goal of ensuring platform readiness. Due to this tight-coupling collaboration, the value co-creation mechanisms scale on neither side. Again, similar mechanisms can be found in other industries. Apple, for example, uses employees from Genius Bars as boundary spanners to help customers use their products or services. In total, this supported readiness illustrates how IoT platforms bridge low structural flexibility by a boundary spanner.

Core value co-creation practice

Last, there is the core value co-creation practice of servitization through application enablement that combines demand- and supply-side practices. The IoT platform acts as a repository connecting customers with the applications and services on the platform. This set-up enables the customer to create his or her own applications (see Fig. 4). On the one hand, demand-side value co-creation practices ensure that customers meet the conditions to use the IoT platform in a plug & play manner. On the other hand, supply-side practices foster resource liquefaction by decoupling information that is available by ecosystem actors such as partners and providing it in an abstracted form on the platform. Furthermore, the platform makes sure that all products and services on the platform comply with the platform standards. In this sense, both value co-creation practices standardize demand and supply to enable the core value co-creation interaction. The customers use the IoT platform as a repository of abstract applications and services. Each application and service can be seen as an ideal type. On an abstract level, a wide range of customers can use each application or service autonomously. However, if a customer applies the app to a specific context, the interpretation of applications changes and transforms toward a specific application that fits the need of a distinct institutional logic. An example is the abstract application of setting-up geofences on a map, where a specific use case can be the tracking of cargo-ships in the maritime industry. In this process, customers combine the applications and services according to their institutional logic to foster generativity. The platform mitigates the problem of data ownership by allowing customers to use the IoT platform on a dedicated or on-premise solution. Also, the platform addresses special requirements targeting availability and security by enabling customers to create applications that fit their institutional logic.

In sum, we show that an AEP co-creates value in three distinct ways. First, the B2B platform tackles the problem of engaging a variety of actors through resource liquefaction on the supply side to make sensors, applications, and services available on the platform. Second, the platform accounts for the complexity of customers' institutional logic by ensuring platform readiness in a standardization process where customers comply with platform standards. Third, the platform facilitates interaction between the supply and demand side by enabling customers to use the AEP as an abstract plug & play toolkit according to their own, specific context. This shifts the satisfaction of special needs, like security, to the customer.

Implications, limitations, and future research

The study provides three implications for theory. First, we show that the S-D framework (Lusch and Nambisan 2015) and the dynamic concept of boundary objects (Star and Griesemer 1989; Star 2010) complement one another regarding the description of value co-creation practices. Boundary objects account for S-D related issues like structural flexibility or provide a shared worldview through a standardized work process that creates boundary objects. One example is the value co-creation process of ensuring platform readiness, where the platform provides boundary resources such as documentations and how-to guides to provide a structure for customers on how to adjust machines, sensors, and processes. Those boundary resources serve as coincident boundaries (e.g., maps) helping customers to comply with platform standards ensuring structural flexibility. The platform follows a similar mechanism on the supply side. Boundary resources such as APIs and SDKs enable a variety of ecosystem actors to integrate complementary assets on the platform. Thus, the platform fosters resource liquefaction and increases resource density, as the resulting applications and services can be shared and used in the platform ecosystem. Those applications and services are boundary resources that are abstract (ill-structured) to be interpreted among different groups and, at

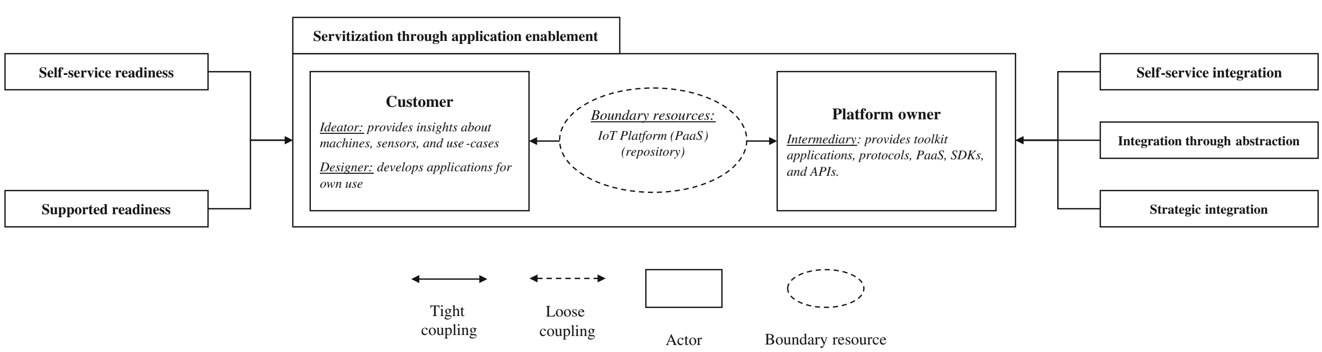


Fig. 4 Core value co-creation practice of servitization through application enablement (own illustration)

the same time, concrete (well-structured) in a specific institutional context. We show that the combination of S-D logic and boundary objects is a fruitful combination to account for potential issues in the value co-creation process such as providing structural flexibility (Lusch and Nambisan 2015). In addition, we supplement existing literature on platform boundary resources (Ghazawneh and Henfridsson 2013; Eaton et al. 2015) by showing how B2B IoT platforms use and combine different types of boundary objects (e.g., ideal types, coincident boundaries, standardized forms, and repositories) in the process of value co-creation.

Second, we show the importance of value co-creation practices in B2B IoT platforms to follow the dynamic process toward standardization (Star 2010). The case study presents insights on how platforms implement standardized work processes to achieve scalable value co-creation practices that foster network externalities (McIntyre and Srinivasan 2017). They do so by shifting the design effort outside of the platform to make ecosystem actors comply with the standardized process. Examples are the supply- and demand-side value co-creation mechanisms of self-service readiness and integration. In both cases, the customer/partner interacts in a loosely-coupled relationship (Orton and Weick 1990) by adhering to boundary resources such as documentation and how-to guides. They adjust their institutional logic to comply with platform standards. The loosely-coupled interaction scales to the end of the platform. Parker et al. (2017) call this effect "inverting the firm." This standardization of value co-creation practices offers another advantage in the form of increased resource density. When partners integrate their resources into the platform, they also comply with the standards required by the platform. The platform orchestrates those abstractions in a repository, which all other parties in the ecosystem can access. This compatibility fosters network externalities as once created application or service cannot only be used by one individual customer but by the whole ecosystem. In addition, this process fosters generativity in the network as parties can use and combine applications and services according to their institutional logic. The residual value co-creation mechanism of integration through abstraction captures the generativity caused by new applications that do not apply to platform standards transforming specific applications toward an ideal type. Through this feedback loop, customers benefit from applications created by peer customers. However, the residual process design effort lies on the platform side, limiting the scalability. In summary, we show that the dynamic standardization process of boundary objects can be applied to value co-creation practices in B2B IoT platforms. The process helps to explain how platforms act as infrastructures that engage their ecosystem to utilize network externalities (McIntyre and Srinivasan 2017; Constantinides et al. 2018; Weking et al. 2018b). Furthermore, we show that the standardization process fosters residual value co-creation mechanisms.

Third, the case study provides insights on B2B IoT value co-creation practices (Constantinides et al. 2018). While previous studies focused on customer service encounters (Giesbrecht et al. 2017) or sole platform to complementor relationships (Sarker et al. 2012; Förderer et al. 2018), we show how platforms account for a variety of ecosystem actors ranging from sensors manufacturers to software developers, and customers by fostering self-service value co-creation mechanisms. The platform controls the process of external contributions (Ghazawneh and Henfridsson 2013) and makes ecosystem actors comply with platform standards. Instead of controlling and integrating each product and service individually, the platform controls the input through strict rules and boundary resources, allowing for a scalable resource integration. To deal with the business-related requirements of customers, platforms take advantage of two different value co-creation mechanisms. On the one hand, the platform provides self-service readiness through boundary resources that make the customer adapt to platform standards. On the other hand, the platform conducts boundary-spanning activities to bridge the gap between customers that are not able to follow the self-service integration mechanism. Boundary spanning activities such as partnerships with consultancies in the form of supported readiness that help customers to align with platform standards. Those mechanisms aim to enable the customer to use the applications and services on the platform like a toolbox, where they can develop solutions to fit their individual needs and internal processes (institutional logic). Last, there is the complexity of IoT services that B2B value co-creation practices must account for. The value co-creation mechanism of strategic integration hints toward the fact that loosely-coupled relationships are not sufficient to standardize the complexity of vertical solutions (Schermuly et al. 2019). On the contrary, the platform relies on tight coupling and strategic partnerships with industry experts to develop an abstract representation of vertical solutions. Based on those industry-specific structures, loosely-coupled partnerships can extend the platform offering of new products or services (e.g., integrating a new sensor that supports a specific production step).

Furthermore, there are implications for practice. First, we show how B2B IoT Platforms integrate and facilitate value co-creation practices toward scalable resource integration and consumption. Second, practitioners can use the S-D framework (Lusch and Nambisan 2015) in combination with the theory of boundary objects (Star and Griesemer 1989; Star 2010) to analyze whether their value co-creation practices have potential for standardization. Thus, platform owner can design new value co-creation practices to shift the design effort outside of the platform, thus leveraging network externalities (Parker et al. 2017). In addition, we show that through the standardization of value co-creation practices, companies need to spend increased awareness of resulting residuals practices.

Last, the study faces limitations. First, the study might not be transferable to other industries because it builds on a multiple case study in the context of IoT platforms. Further studies can conduct additional case studies in industries that are evolving towards platform businesses to increase the generalizability across industries (Yin 2014). Second, the interviews cover only the platform owner perspective, which limits the robustness of the findings. While we tried to mitigate this limitation based on a sampling strategy that covers interviewees with profound customer interaction (e.g., sales lead and technical consultants), additional interviews with customers could reveal more insights about the perspective of ecosystem actors. Also, the findings are based on qualitative data, thus providing only fist hunches of possible value co-creation practices. Interesting areas for future research could develop a process model on how platforms foster the standardization of value co-creation practices and how residual value co-creation practices emerge. Such a model would provide answers about whether residuals originate as a consequence of workarounds or if they can be strategically designed to mitigate problems arising from structural flexibility (Eaton et al. 2015). Also, are residual value co-creation mechanisms going to be standardized as well and who is triggering this process? Furthermore, the study focuses only on the mechanisms that develop new products utilizing technology and value co-creation. As an extension, Alves et al. (2016) identified two additional clusters, namely the co-creation experience from the customer's point of view, and the relationships between customers and platforms, which are not considered in this case study. Thus, further interviews from the perspective of the customers and partners could provide important insights on those two aspects.

Conclusion

During the last years, we have seen a shift in how companies create value. Starting from value creation processes inside the firm, service platforms have emerged and turned the value creation process into a mutual value co-creation process with an ecosystem of actors. While there is research on how platform leaders in the B2C business such as Facebook or Apple co-create value, research on emerging B2B platforms is still sparse. In contrast to B2C platforms, B2B platforms need to establish value co-creation practices under more complex conditions. They need to encourage a variety of ecosystem actors and interact with customers that are harder to satisfy due to their requirements as legal entities, and in an often more complex environment. One particular example are IoT platforms that need to integrate sensor manufacturers, service and application developers, and industry customers by providing services that range from device management to database storage and data analytics.

We show that the combination of the service-dominant (S-D) framework of Lusch and Nambisan (2015) with the dynamic process of boundary objects (Star and Griesemer 1989; Star 2010) provides a fruitful combination to describe and analyze value co-creation practices. By combining those two theoretical perspectives, we can illustrate that IoT platforms follow a standardization process to encourage the supply and demand side to comply with industry standards. The resulting application enablement platform includes three main value co-creation practices: the integration of complementary assets representing the supply side, the assurance of platform readiness for the demand side, and servitization through application enablement as a core co-creation practice. The main achievement of platforms is the high degree of standardization of value co-creation practices by shifting the design effort to the ecosystem in turn leveraging network externalities. Also, we show that a consequence of the standardization process are residual value co-creation practices that result from customers and partners unable to comply with platform standards.

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