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Opening the Black Box of Digital B2B Co-Creation Platforms: A Taxonomy

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Abstract. Digital B2B platforms are becoming increasingly important for value co-creation in today's business networks, leading to the emergence of a diverse landscape of platforms and intensifying research efforts. Yet, practitioners and researchers alike lack a means to structure existing knowledge and distinguish between different B2B platforms. In this paper, we apply Nickerson et al.'s method for taxonomy development to derive a taxonomy of B2B co-creation platforms drawing on 36 research articles and 63 real-world platform cases. We find 17 dimensions that describe B2B co-creation platforms in terms of their platform architecture, their actor ecosystem, and their value creation process. Thereby, we contribute to research and practice: First, we provide a holistic perspective on B2B co-creation platforms by aggregating existing knowledge and identifying the fundamental properties relevant for their distinction. Second, we provide a decision aid for practitioners to evaluate which platform to join or how to design B2B co-creation platforms.

Keywords: Digital B2B platforms, Platform taxonomy, Co-creation

1 Introduction

Digital platforms—as a business and organizational model—are one of the key drivers of digital transformation [1, 2]. In the B2C sector, digital platforms, like Google, Facebook, or Airbnb, often have an almost monopolistic status and continue to maintain their position [3]. In contrast, the landscape of digital platforms in the B2B sector is more scattered: Aiming to tap their potential to foster collaboration and co-creation of value [1], we observe intensified efforts to establish and operate own digital platforms (e.g., GE Predix [4], thyssenkrupp toii [5]). Accordingly, companies aiming to join other parties' platform ecosystem, are challenged with reviewing and comparing an ever increasing number of digital platforms with different application-, industry- and technology-foci [6].

Hence, practitioners and researcher alike would benefit from a comprehensive view on B2B platforms and their respective characteristics. While prior research has already made attempts to aggregate and structure knowledge on B2B platforms, they are either limited to a specific perspective (e.g., technical platform architecture [7], platform complementors [8]) or type of platform (e.g. IIoT platforms [9]). Therefore, this paper

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aims to lay the foundation for holistically classifying digital B2B co-creation platforms by consolidating existing knowledge in the form of a taxonomy. Taxonomies have proven to be a valuable tool to understand, analyze, and structure the knowledge within emerging research fields [10]. Hence, the following research question can be formulated: *What are the conceptually grounded and empirically validated characteristics that describe B2B co-creation platforms?*

The taxonomy development follows the process of Nickerson et al. [10]. Building on a data corpus of 63 real-world platform cases and 38 academic articles identified by a structured literature review [11], we iteratively develop our taxonomy. We determine 17 key dimensions (e.g., core value proposition, platform openness, and complementor types) that systematically characterize B2B co-creation platforms. The final taxonomy is evaluated regarding its usefulness and general applicability.

Our taxonomy contributes to theory and practice: On the one hand, it provides a comprehensive reference work that takes a holistic view on B2B co-creation platforms instead of focusing on selected aspects. Therefore, is represents a tool for researchers to systematically compare platforms, position their research, and identify research directions. On the other hand, it enables practitioners to compare and benchmark different platforms, and to identify options for platform design.

This paper is structured as follows. Section 2 provides an overview of extant literature on B2B platforms and existing attempts to structure this knowledge. Section 3 describes the methodological approach to develop the taxonomy, which is presented, applied and evaluated in section 4. Finally, section 5 concludes the paper with a discussion of the taxonomy's implications and future research opportunities.

2 Background

Originally defined as "layered modular technology architectures in business networks" [12, p. 186], digital platforms represent socio-technical systems that enable and coordinate the interaction of actors and resources in an ecosystem facilitating value co-creation and innovation [1, 7, 13]. By providing a stable core, whose functionality can be extended with modular services [14, 15], digital platforms are an essential means for facilitating collaboration between firms, innovation, and, thus, value co-creation in today's service ecosystems [2, 14, 16]. Especially, in the realm of business-to-business interactions, digital platforms become increasingly popular, leading to the development of a diverse platform landscape [1]. For example, we find data platforms such as *AVIATION DataHub* that bring together data from the aviation industry and facilitate data exchange [17]; industrial internet of things (IIoT) platforms such as *Cumulocity IoT* that integrate physical devices of manufacturers and allow third parties to provide additional resources or develop complementary applications [18]; supply chain management platforms such as *RailSupply* that foster the communication and collaboration of firms across the supply chain; or cloud platforms such as *Azure IoT* that offer flexible and scalable IT resources as a service. Further, there are retail platforms such as *WUCATO* that provide marketplaces for products and services bringing together the supply and demand side. Yet, in our paper, we focus on digital platforms that enable value co-creation of different actors directly on the platform. Thus, we refer to *B2B co-creation platforms* as *modular structures that enable the interaction of actors and resources to facilitate value co-creation* [13, 19]. These digital platforms are particularly important for businesses in today's competitive environment as they facilitate effective and efficient information exchange, integrate resources across firm boundaries, thereby facilitating joint innovation and value co-creation, enabling new business models and, thus, ultimately promoting long-term market success. These benefits encourage companies to join B2B platforms or even develop their own ones. However, as the range of available digital platforms is diverse and often difficult to assess, the need for a means to structure and analyze them arises.

The literature offers several approaches for structuring and classifying digital B2B platforms and their surrounding ecosystems: Guggenberger et al. [20] provide a typology of generic ecosystem configurations aggregating different ecosystem conceptualizations in IS research. Yet platforms as the core of ecosystems are not considered in depth. Furthermore, they solely take a literature-based approach and do not include practice-oriented findings. Engert et al. [8] focus on the aspect of platform complementors and develop a taxonomy for complementor assessment by conducting a multiple-case study on the partner programs of 14 B2B software platforms. Even though they propose criteria and metrics for assessing platform complementors, they neither consider the platforms' architecture nor the value creation processes. Blaschke et al. [7] take a technical view on platforms' architecture developing a taxonomy to distinguish digital platforms based on their underlying technical configuration of components. For example, they provide insights into platform access options (e.g., open standards, devices) and technical core artefacts of software and hardware, however the network of actors and their relations, as well as complementor roles are not in the scope of their taxonomy. While Blaschke et al. [7] focus on technical aspects, Hodapp et al. [9] limit their study to a business view investigating IoT platforms' business models. The authors analyze 195 IoT platforms to characterize their business model and derive IoT business model archetypes. Similarly, Täuscher and Laudien [21] examine the business model characteristics of platforms with a focus on marketplaces in the areas of C2C, B2C, and B2B. However, both articles focus a specific platform type (i.e., IoT platforms or marketplaces) and do not consider further value co-creation activities or facilitating platform characteristics. Summing up, all these approaches to structure and analyze digital B2B platforms are limited either on certain aspects of the platform or on specific platform types, which further emphasizes the need for a comprehensive characterization that reflects the diverse nature of B2B co-creation platforms.

3 Methodology

We aim to identify characteristics of digital co-creation platforms in the B2B field, which serve as basis for the discrimination of platform types and provide assistance for their design. For that purpose, we develop a taxonomy following Nickerson et al. [10]. A taxonomy is a set of dimensions used to classify objects of interest [10]. Mutually exclusive and collectively exhaustive characteristics construct each dimension, i.e., in each dimension, each object must exhibit precisely one characteristic [10].

The taxonomy development method is an iterative method. It starts with the definition of the meta-characteristics and ending conditions. The meta-characteristic is an initial comprehensive characteristic, which will serve as the basis for the choice of characteristics in the taxonomy [10]. Ending conditions define the state in which the taxonomy development process is terminated. Nickerson et al.'s process [10] includes seven steps that are iteratively repeated until the ending conditions are met. For each iteration, either a conceptual-to-empirical or empirical-to-conceptual approach must be selected. Conceptual-to-empirical is a deductive approach in which the taxonomy's dimensions are conceptualized first, and then the dimensions' characteristics are identified. The empirical-to-conceptual approach in turn, examines real-life objects and identifies their common characteristics that are grouped into dimensions.

3.1 Input Data for Taxonomy Development

As a basis for the development of the taxonomy an extensive data corpus is compiled with both scientific literature and real-world platform cases from practice. For the conceptual-to-empirical approach, we rely on dimensions that have previously been identified in the literature. We therefore conduct a systematic literature review following Webster and Watson [11]. The search string *[(platform AND ecosystem) OR ((platform OR ecosystem) AND (digital OR B2B OR industry OR IoT OR business))]* is applied to the title of articles in four databases: AISeL, Scopus, EBSCOhost, and Web of Science. The AISeL database provides a distinct information systems perspective, while the others provide a more general and interdisciplinary view on research on B2B platforms.

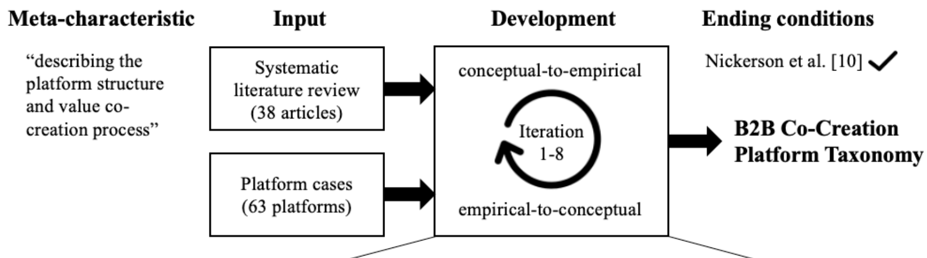
The search yields 3948 unique search results, which are screened for relevance by screening their title, abstract, and full text. The literature screening and reduction follows a three-step process: First, we consider the title and reduce the literature base to 395 articles. Only articles that deal with the research objectives in a non-trivial and non-marginal way are included in the literature base. Articles that do not exhibit a relevant domain focus or context (i.e., IS, business, or B2B focus) are excluded. Thus, articles from the domains of medicine, biology, media, or physics, articles with a clear B2C focus, and articles with a purely technical focus (e.g., middleware) are excluded. Second, we screen the abstracts to exclude articles that only marginally cover value co-creation platforms, leaving 82 articles. For example, we exclude articles examining pure marketplaces or platforms that are used as passive information repositories. Third, by screening the full text we arrive at 29 articles that can provide meaningful insights (i.e., dimensions, platform characteristics) for the taxonomy development. Finally, after the screening process and a backward and forward search 38 relevant articles remain, which build a sound basis for the conceptual-to-empirical taxonomy development approach.

Following the empirical-to-conceptual approach, we draw on real-world platform cases. A total of 63 real-world platforms are identified by (1) screening the publications identified for cases mentioned and (2) by referring to reports from German public research institutes and industry associations [6, 22–25]. Following, we collect publicly available information on the 63 platforms. Information sources include primary sources (e.g., the platforms' websites or press releases), and secondary sources (e.g., analyst reports, YouTube videos, tech blog entries) [26]. We analyze the collected data applying qualitative content analysis [27], which is supported by the software MAXQDA. This systematic approach allows to identify characteristics of B2B co-creation platforms that serve as input for the taxonomy development process.

3.2 Taxonomy Development

The taxonomy development process starts with definition of the meta-characteristics and ending conditions. The meta-characteristic is formulated as "describing the platform structure and value co-creation process", hence it adapts to the taxonomy purpose of distinguishing platform instances. Second, we define the ending conditions that terminate the taxonomy development: both the eight objective and five subjective ending conditions from Nickerson et al. [10] are adopted. Third, we start the iterative part of the development process with the first iteration choosing the conceptual-to-empirical approach to build on the foundation of existing research. The final taxonomy of B2B co-creation platforms is developed throughout eight iterations: Iterations one and six follow the conceptual approach, whereas iterations two to five, seven and eight follow the empirical approach. In each iteration we revise the initial dimensions and characteristics of the B2B co-creation platform taxonomy by repeatedly examining sets of platform objects (empirical-to-conceptual approach) or refining dimensions and characteristics based on scientific literature (conceptual-to-empirical approach).

Figure 1 visualizes the taxonomy development process and presents an overview of the iterations and modifications to the taxonomy. In particular, iteration one establishes the initial taxonomy with 23 dimensions, which is refined in iterations two to five by adding and revising characteristics and dimensions based on real-world platform cases. This process leads to 24 preliminary dimensions, as the dimension *revenue stream* is split up into *revenue stream from complementors* and *revenue stream from users* to better reflect relevant differences in real-world platforms. Iteration six pursues the goal to consolidate previously identified dimensions to improve the taxonomy's conciseness. Therefore, the preliminary 24 dimensions are consolidated to 17 dimensions based on scientific literature. Iteration seven leads to no further changes and after the eighth iteration, all objective and subjective ending conditions are met. Thus, the taxonomy development process ends. The final taxonomy comprises 17 dimensions with the corresponding characteristics that comprehensively classify B2B co-creation platforms. Since the taxonomy's purpose is to provide a valuable tool to researchers and practitioners to distinguish and eventually design B2B platforms, we subsequently evaluate the taxonomy regarding its usefulness and ease of use [10] and demonstrate its applicability.



It.	# Dim.	Modifications
1 c	23	Established initial taxonomy
2 e	23	Examined first 10 platform objects (POs)
3 e	24	Examined 10 POs, split up dimension "revenue stream"
4 e	24	Examined 10 POs, revised characteristics and dimensions
5 e	24	Examined 10 POs, revised characteristics and dimensions
6 c	17	Consolidated the dimensions based on the literature to make the taxonomy more concise and robust
7 e	17	Examined 10 POs, no more changes
8 e	17	Examined remaining POs and reviewed ending conditions
Key: c = conceptual approach, e = empirical approach, PO = platform object		

Figure 1. Taxonomy development process

4 Results

In this section, we first present the developed B2B co-creation platform taxonomy. We find that B2B co-creation platforms can be distinguished according to their value creation process, their platform architecture, and their actor ecosystem, which we structure in 17 dimensions. Furthermore, we present the evaluation results that confirm the usefulness of our taxonomy. Lastly, we demonstrate the taxonomy's applicability by classifying all 63 platform instances, two of which are illustrated, and outline initial insights on the landscape of B2B co-creation platforms.

4.1 B2B Co-Creation Platform Taxonomy

Drawing on existing literature and 63 real-world platform cases, we find that B2B co-creation platforms can fundamentally be classified by their value creation, their architecture, and their actor ecosystem. These three essential distinguishing properties are specified in 17 dimensions that constitute the taxonomy and provide a first answer to the posted research question. Figure visualizes the taxonomy as a morphological box as it grants intuitive insight into the structure [28].

Value creation. The dimensions summarized as value creation address the unique value that is offered by the platform and describe how this value is created. Therefore, the taxonomy includes the core value proposition offered to platform participants, the medium of exchange, the revenue streams from complementors and users, as well as the options provided to users to extend the platform according to their own needs.

Core value proposition (What are the core capabilities offered by the platform?): Our study unveils that platforms offer six core capabilities: Whereas some platforms only offer basic *device connectivity and management services* (e.g., Telekom Cloud of Things, Cisco Jasper Control Center), others additionally offer *advanced analytics* capabilities (e.g., Flutura Cerebra) or *orchestrate a network*, i.e., optimize the collaboration and exchange between the platform members, often in a supply-chain context (e.g., VW Discovery). On *exchange* platforms, physical or virtual goods and services are traded (e.g., Telekom Data Intelligence Hub) and platforms with a *Cloud PaaS* capability offer a collection of fully managed tools to connect assets, manage and analyze data, and support the development of new solutions (e.g., Azure IoT, AWS IoT Core). The characteristics *IIoT enablement* refers to platforms that offer connectivity capabilities, data analytics, tools for developers, and applications and services in the domain of industrial applications (e.g., Siemens MindSphere, ADAMOS).

Options for extensibility (How does the platform enable the user to extend the platform?): This dimension can be split into five characteristics. While some platforms do *not allow users to extend the platform* (e.g., SupplyOn Railsupply), the majority provides this option through additional code. In particular, platforms either provide a highly abstracted *low code environment* (e.g., Flutura Cerebra), or, in other cases, more programming *code-based* effort in a dedicated programming language (e.g., Exosite Murano) is required. Similarly, in an *open-source* approach, the platform can be extended through open-source interfaces and programming languages (e.g., Kaa IoT) or even *multiple* options are offered (e.g., GE Predix).

Medium of exchange (What is the primarily exchanged on the platform?): Platforms create value by exchanging various items [29]. These can be pieces of *information* (e.g., in the case of SAP AIN), *data* (e.g., Telekom Data Intelligence Hub), *services* (e.g., Homag tapio), or also *multiple* items, including the simultaneous exchange of capacity and services (e.g., Siemens MindSphere).

Revenue stream from users (How does the platform owner capture value from the platform users?): Our study finds seven characteristics that describe the revenue stream from platform users [30]. While some platforms offer their services *free* of charge (e.g., Lufthansa Technik Aviation Data Hub), most platforms apply one or *multiple* (e.g., SAP Cloud Platform) of the following revenue models. *Freemium* models offer platform users basic functionalities for free and charge for additional services (e.g., Siemens Healthineers teamplay). In the case of a *transaction-based* revenue model (e.g., HPE Universal IoT Platform) the user is charged for different kinds of transactions (e.g., per connected device, per API call, or generated traffic [31]) while in the commonly used *subscription-based* model (e.g., ABB Ability) users pay a fixed subscription fee. A *hybrid* model combines the subscription- and transaction-based revenue model, i.e., the platform charges a recurring fixed fee plus transaction-dependent costs (e.g., Bosch IoT Suite). A few platforms also offer a *license* model (e.g., BEDM Industrie 4.0 Framework).

Revenue stream from complementors (How does the platform owner capture value from the platform complementors?): The platform owner also generates revenue through the complementors either by a *transaction-based* revenue model (e.g., Cogobuy) where the complementor is charged per transaction (e.g., per connected device, per API call, or generated traffic [31]), or a *subscription-based* model (e.g., DKE Agrirouter), or *licensing* (e.g., Exosite Murano). In addition, some platforms do *not charge* their complementors (e.g., Telekom Data Intelligence Hub).

	Dimension	Characteristics						
Value creation	Core value proposition	Device management	Analytics	Network orchestration	Exchange	Cloud PaaS	IIoT enablement	
	Options for extensibility	None	Low code	Code-based	Open source	Multiple		
	Medium of exchange	Information	Data	Services	Multiple			
	Revenue stream from users	None	Freemium	Transaction -based	Subscription -based	Hybrid	License	Multiple
	Revenue stream from complementors	None	Transaction-based	Subscription-based	License			
Platform architecture	Platform integration	Stand-alone	Vertical	Horizontal	End-to-end			
	Platform openness	Fully proprietary	Hardware proprietary	Software proprietary	Open source			
	Decisional openness	Lead organization-governed	Participant-governed					
	Complementor openness	Open	Conditions for access	Selected partners	Closed			
	Type of support	Non-personal technical support	Personal technical support	Personal technical and business support				
Actor ecosystem	Industry focus	Single vertical industry	Multiple vertical industries					
	Origin of platform	Company internal	External customers in own domain	External customers in new domain				
	Geographic distribution	National	Regional	International				
	Platform owner	SME	Large enterprise	Joint venture	Open source			
	Platform owner background	IT and software systems	Automation, control and equipment systems	Telco and carrier systems	Automotive	Aviation and aerospace	Emergent innovator	Mixed
	Complementor types	None	Technology partner	Resource integrator	Technology & integration	Technology & resource	All types	
	Participation incentives	None	Non-monetary	Monetary and non-monetary				

Figure 2. B2B co-creation platform taxonomy

Platform architecture. The dimensions summarized as platform architecture describe the fundamental organizational layout of the platform, including its components and governing principles. On the one hand, the taxonomy specifies how the platform is integrated in businesses' IT systems and what type of support is offered to participants and on the other hand, it looks into different aspects of openness, i.e., platform openness, decisional openness, and complementor openness.

Platform integration (How is the platform integrated into the business' IT system?): Regarding a platforms integration into the business' IT system, we find four characteristics [32]: The *vertical* integration means that various IT systems are integrated at different hierarchical levels (sensor-to-ERP) (e.g., HPE Universal IoT Platform, Cisco Jasper Control Center) while *horizontal* integration refers to the integration of various IT systems used in different stages of the value chain (e.g., Crowdfox). *End-to-end* integration combines both horizontal and vertical integration (e.g., Software AG Cumulocity IoT), in contrast to a *stand-alone* solution that is not integrated into the business's IT system (e.g., Telekom Data Intelligence Hub).

Platform openness (How open is the platform towards external modifications to the platform’s underlying code?): For the platform’s openness, which is defined as "the extent to which platform boundary resources support complements" [1, p. 127]), scholars distinguish between four characteristics [33]. First, *fully proprietary* means that external developers have no access to modifying the platform's underlying code or exchange data with the platform on open source-based interfaces. Second, when the *hardware is proprietary*, only specific devices can be integrated into the platform, for example, only specific devices can transfer data to the platform (e.g., Schaeffler Smart Ecosystem). Third, *software proprietary* means that the platform can be run on any device, but the platform code is not openly accessible (e.g., PTC Thingworx). Fourth, in an *open-source* approach the platform can run on any third-party device and the platform code is open to external modifications (e.g., ADAMOS).

Decisional openness (Who holds the decision-making authority?): We find two typical governance models [34]: In a *lead organization-governed* platform all key decisions are made by a single participating member, usually the platform owner, which leads to a highly centralized and asymmetrical power distribution [35] (e.g., Siemens MindSphere, Telekom Data Intelligence Hub). In multi-firm strategic alliances or partnerships (e.g., ADAMOS, DKE Agrirouter) [35] often the platform members themselves govern the platform, which is called a *participant-governed platform*.

Complementor openness (How open is the platform for complementors?): Four different complementor openness characteristics can be distinguished [13]: The two edge cases are a fully *closed* platform that does not allow complementors to join at all (e.g., ZF Openmatics) and an *open* platform where any complementor is free to join (e.g., DeviceHive IoT). Apart from these, a platform owner can dictate *specific conditions for complementors* to join and offer their services on the platform (e.g., Ayla Agile IoT Platform) or the owner may invite *selected partners* to join (e.g., Flutura Cerebra).

Type of support (What type of support does the platform offer for participants?): The level of support ranges from *non-personal technical support* providing documentation and online forums (e.g., Flutura Cerebra), to additional *personal technical support* teams (e.g., Lufthansa Technik Aviatar), to full *personal technical and business support* including business consulting services related to the platform (e.g., DeviceHive IoT).

Actor ecosystem. The dimensions summarized as actor ecosystem describe platform participants and their roles. In particular, it provides an overview of the platform’s origin and geographic as well as industry focus, the platform owner and its background, and the complementors including the incentives to join.

Industry focus (What is the target market of the platform?): Either a platform focuses on a *single vertical industry*, e.g., discrete manufacturing, aviation, and healthcare (e.g., Siemens Healthineers Teamplay), or it targets *multiple different verticals* simultaneously (e.g., PTC Thingworx) [33].

Origin of solution (Why was the platform originally developed?): This dimension describes whether the platform was developed for internal use or external customers. In particular, some platforms (e.g., GE Predix, Thyssenkrupp toii) were initially developed for a *company internal use* and only later offered to external customers. In contrast, others were explicitly developed as a platform for *external customers*, either targeting the company's *primary domain of expertise* (e.g., Siemens MindSphere, Lufthansa Technik Aviation Data Hub) or focusing on a *new domain* (e.g., Software AG Cumulocity IoT).

Geographic distribution (How is the platform positioned globally?): We find that platforms either focus on a *specific country* (e.g., Hitachi Lumada), *region* such as DACH or SE Asia (e.g., Davra IoT Platform), or they pursue an *international* strategy (e.g., Homag tapio) [36].

Platform owner (Who holds the ownership rights to the platform?): Scholars distinguish between four owners [30], namely *SME*, *large enterprise*, *joint venture*, and *open source*. For our taxonomy we adopt the European Commission's definition of a SME (e.g., Flutura) and large enterprises (e.g., Siemens) [37] and refer to joint ventures when a merger of two or more companies establish a platform (e.g., DKE Agrirouter), or to open source when the platform results from an open-source project (e.g., DeviceHive IoT).

Platform owner background (What is the platform owner's main domain of expertise?): Our study reveals five distinct backgrounds, namely *IT and software systems* (e.g., SAP Cloud Platform); *automation, control and equipment systems* (e.g., Bosch IoT Suite); *telco and carrier systems* (e.g., Telekom Data Intelligence Hub); *aviation and aerospace* (e.g., Lufthansa Technik Aviatar); *automotive* (e.g., ZF Openmatics); and *emergent innovator* (e.g., QiO Foresight) meaning that the owner is a new market entrant. Lastly, in *joint ventures* (e.g., ADAMOS), *mixed* backgrounds can also occur.

Complementor types (Which types of complementors are active on the platform?): Three different types of complementors can be part of a platform and appear *alone* or *together* in different permutations. *Technology partners* include software and hardware developers as well as cloud infrastructure providers. *Integration support* refers to system integrators that support the platform's technical implementation, and consulting firms that offer business consulting and transformation services in connection with the platform. The third type of complementors are *resource integrators*, i.e., firms that provide tangible and intangible types of resources, such as data, physical products, manufacturing capacity, or financing. These three complementor types can appear in five different permutations or not at all, as is the case when the platform owner provides all these services.

Participation incentives (How does the platform owner incentivize complementor participation?): Some platforms offer *no explicit incentives* to complementors to join the platform (e.g., Lufthansa Technik Aviatar), while others offer *non-monetary* incentives such as sales and technical training, application developer tools or technical support (e.g., QiO Foresight) or a combination of these *non-monetary incentives with monetary incentives* such as discounts or access to business developer funds (e.g.; Siemens MindSphere) [38].

4.2 Taxonomy Evaluation and Demonstration of Application

The taxonomy is evaluated with regard to its usability and applicability. To assess its usability, eight experts—four selected for their theoretical knowledge and four chosen for their practical experience with B2B platforms—are asked to classify two real-world platforms using the taxonomy. We chose Siemens MindSphere and Telekom Data Intelligence Hub as cases for the evaluation, as they differ greatly and provide extensive publicly available information. Subsequent to the classification, the experts are asked to evaluate the taxonomy's perceived usefulness and ease of use with survey items adapted from Davis [39]. The evaluation results indicate that our taxonomy of B2B co-creation platforms is useful (mean = 6.3, SD = 0.4, scale from 1 = extremely unlikely to 7 = extremely likely) and easy to use (mean = 6.0, SD = 0.5, scale from 1 = extremely unlikely to 7 = extremely likely). Furthermore, it fulfilled the experts' expectations (mean = 6.4, SD = 0.5, scale from 1 = extremely unlikely to 7 = extremely likely) and is extensive (mean = 6.1, SD = 0.3, scale from 1 = extremely unlikely to 7 = extremely likely). Moreover, the high classification agreement (Siemens case: 69.9%, Telekom case: 70.1%) among the experts illustrates the taxonomy's ability to classify B2B platforms consistently. As a consequence of the evaluation, the description of the dimension *platform integration* was revised to enhance its clarity. To demonstrate the taxonomy's practical applicability and capability to characterize B2B co-creation platforms, we classified all 63 platform objects of our data corpus. Figure 3 shows the frequency of each characteristics' occurrence across all platforms and visualized exemplary platforms: Siemens MindSphere and Telekom Data Intelligence Hub.

Siemens MindSphere is an IIoT enablement platform that operates internationally in multiple vertical industries. It offers ample ways for customers to create value by providing, among other things, end-to-end integration, a low code environment and the possibility to integrate open-source software. Open application programming interfaces enable customers to connect their machines and equipment to the platform to exchange data and value-adding services. The ecosystem consists of Siemens, a large enterprise that owns and governs the platform, customers from Siemens' domain of expertise (i.e., automation, control, and equipment systems) and technology partners as well as complementors offering integration support. Complementors are offered monetary and non-monetary incentives to join, yet they must meet certain conditions and pay a subscription fee. In contrast, the core value proposition of Telekom's international platform Data Intelligence Hub is the exchange of data. Telekom, with a background in telco and carrier systems, retains sole decision control on the platform, which is used by a wide range of customers that mainly are from outside Telekom's core domain of expertise. Users can extend the stand-alone platform by using open-source interfaces, whereas external developers are not allowed to extend the underlying code. While all types of complementors can freely join without any payment, Telekom does not offer explicit participation incentives.

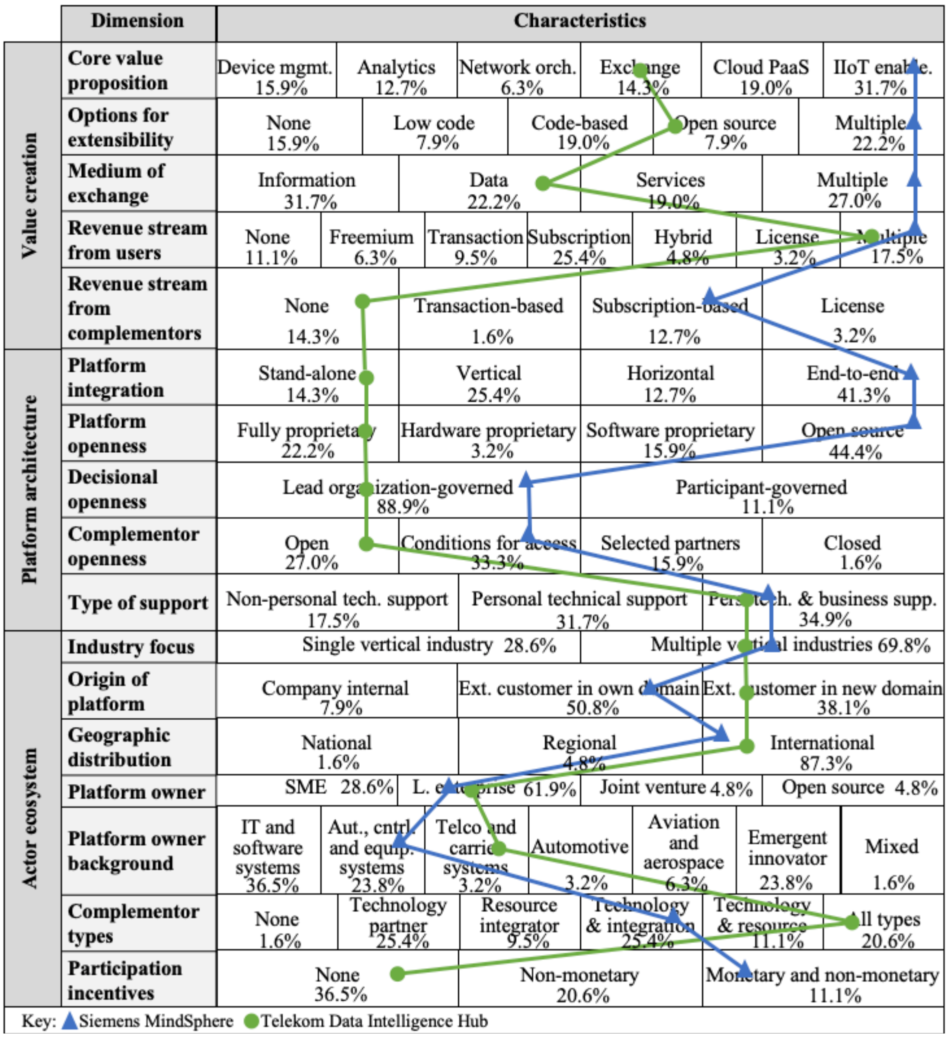


Figure 3. Application demonstration of proposed taxonomy[1]

When comparing the taxonomy characteristics' occurrences across all 63 platforms, it stands out that the core value propositions *Cloud PaaS* and *IIoT enablement* are the most common in the data set. To support the value creation process, the majority of platforms (57%) offer at least one option for extensibility, while 22.2% even offer multiple. The revenue models vary widely, with a tendency towards *subscription-based*

[1] The missing percent to 100 are platforms for that not enough data was available to classify.

revenues from users as well as complementors. Regarding the platform architecture, a high divergence can be observed. However, an *end-to-end platform integration* (41.3%) and an *open-source* approach (44.4%) to platform openness are predominant. Most platforms *limit complementor access* (50.8%), while providing extensive support to their users. Looking at the actor ecosystem, additional insights can be derived: *Large enterprises* (61.9%) stand out as platform owners, while *joint ventures* (4.8%) or *open-source projects* (4.8%) only rarely occur. Although the two dominant platform owner backgrounds are *IT and software systems* (36.5%) and *automation, control and, equipment system*s (23.8%), almost a quarter of platforms is owned by *emergent innovators* (23.8%). The majority of platforms (88.9%) were *initially developed for external customers*, primarily in the *platform owner's main domain of expertise* (50.8%). Furthermore, 69.8% of platforms target *multiple vertical industries*, most often on an *international level* (87.3%). 27% of platforms are *entirely open* to complementors with *technology partners* (25.4%) being the prevalent complementor type, either on their own or in *combination with other partners*.

5 Discussion and Conclusion

This study aimed at identifying the conceptually grounded and empirically validated characteristics that describe B2B co-creation platforms. Therefore, we propose a taxonomy of B2B co-creation platforms highlighting their distinguishing features and building blocks. Thereby the paper provides a comprehensive view on this emerging research field, and a useful tool to classify B2B platforms. Drawing on 38 articles identified by a structured literature review [11] and 63 real-world platform cases, we ensure scientific and practical grounding.

Following the approach of Nickerson et al. [10], 17 dimensions describing and distinguishing B2B co-creation platforms form our final taxonomy. These dimensions describe a platform's value creation process, the platform architecture, and the actor ecosystem. Usefulness and ease of use is demonstrated by an expert evaluation. Furthermore, the taxonomy's applicability is shown and initial insights on the landscape of B2B co-creation platforms are presented.

Hence, our taxonomy of B2B co-creation platforms entails important implications for research and practice. The scientific contribution stems from a comprehensive analysis and structuring of knowledge within the emerging research field of B2B platforms. By aggregating the existing knowledge, we provide a sound foundation for future work. Furthermore, our taxonomy is one of the first to take a holistic perspective, rather than focusing on single platform types or specific platform aspects. It thereby contributes to a clear differentiation of the various B2B co-creation platforms and identifies fundamental characteristics to distinguish them.

Practitioners may benefit from the taxonomy's ability to facilitate decision-making and design: Being able to distinguish B2B co-creation platforms along 17 dimensions, allows decision-makers to structure their assessments and informs decision-making in terms of platform selection and joining. Furthermore, platform owners and designers are put in the position to emphasize their competitive advantage and discover potential for improvement by systematically comparing their own platform to competitor solutions.

Although the taxonomy is developed applying a theoretically founded and empirically validated approach, our study is not free of limitations. Even Nickerson et al. [10] acknowledge that a taxonomy can never be optimal, it still provides an effective means to analyze and structure knowledge on a topic. First, Nickerson et al.'s [10] method for taxonomy development only provides basic guidelines and heuristics for a taxonomy development process. Hence, the results are not free of ambiguity. Second, we explicitly excluded pure marketplaces for the taxonomy development, as our goal was to specifically investigate platforms that enable the interaction and collaboration of actors. Therefore, the taxonomy may be extended to additionally incorporate the distinguishing aspects of this type of B2B platforms. Third, we rely on a set of 63 real-world platforms and corresponding publicly available information to develop the taxonomy. As the market of B2B platforms is rapidly developing, there might be more platforms and information that has not yet been considered in our study. By including a greater number of platform cases, the taxonomy development process might further be improved. Forth, we are aware that the evaluation results are limited in their generalizability. Applicability was demonstrated by classifying the set of platform cases that were used to develop the taxonomy. Moreover, the limited number of evaluation participants only provides initial indication for the taxonomy's usability.

By providing a concise and robust taxonomy of B2B co-creation platforms we enable a common understanding among researchers and, hence, lay the foundation for future research. Addressing the limitations of this study, future research should collect more platform cases to validate the taxonomy and evaluate it with a larger group of experts with different perspectives (e.g., platform owner, platform participants). More important, our taxonomy provides the basis for a deeper theorizing process. Subsequent research may build on our taxonomy and conduct a cluster analysis to identify archetypes of B2B platforms. Using the taxonomy, typical characteristics of these archetypes could then be described and condensed in profiles. This way, the cluster analysis not only unveils prevalent platform types, but also enables the identification of the properties of successful platforms. Further qualitative and quantitative studies should then deepen the investigation of success factors of B2B platforms. Qualitative studies could examine why certain design choices are made and how different platform designs are perceived by the platform participants. For example, interviews with complementors could bring additional insights on how different platform architectures and governance principles resonate with platform participants. In addition, quantitative studies might be used to examine the effect of different platform configurations on platform success. For example, one could compare how different levels of platform and complementor openness affect platform growth. Longitudinal studies may complement this research by providing insights into the evolution of B2B platforms and their distinct characteristics. Finally, all these research efforts lead to a better understanding of B2B co-creation platforms and facilitate their development and design.

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