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Exploring the Determinants of Partner Management in IIoT Platform Ecosystems

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Purpose: This study aims to determine the current state of research on partner management in the context of IIoT platforms that rely on partnerships and act as innovation engines.

Design/Method/Approach: The applied research method is a systematic literature analysis supported by a concept-centric synthesis. The literature sample comprises thirty papers.

Findings: The results indicate that few frameworks exist to improve and professionalize partner management in practice, and only a few papers focus on IIoT platform ecosystems. In contrast, some articles empirically examine individual determinants of partner management in detail. Based on these results, a conceptual framework is derived to organize and distinguish the determinants of partner management and the related concept of partner programs.

Theoretical Implications: The study contributes to the research stream on partner management in IIoT platform ecosystems and enterprise software ecosystems, synthesizing the existing research and highlighting the importance of curated support of partners as a competitive lever between platform ecosystems competing in the same domain.

Practical Implications: Practitioners can use the derived framework to structure partner management activities and make more informed decisions based on the structured view of decisions summarized in the conceptual framework.

Originality/Value: Due to the critical role of complementary partners in innovating upon IIoT platforms the framework is an important foundation for further research on the individual determinants of partner management in the context of digital platforms.

Research Limitations/Future Research: The derived conceptual framework was not empirically validated. Empirical follow-up research could refine and develop the framework into a taxonomy using systematic procedures.

Paper Type: Conceptual

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Дослідження детермінант управління партнерами в екосистемах платформ IIoT

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Мета роботи: Це дослідження має на меті визначити поточний стан досліджень з управління партнерами в контексті платформ IIoT, які покладаються на партнерські відносини та діють як двигуни інновацій.

Дизайн / Метод / Підхід дослідження: Застосований метод дослідження - систематичний аналіз літератури, підкріплений концептуально-орієнтованим синтезом. Вибірка літератури складається з тридцяти статей.

Результати дослідження: Результати свідчать про те, що існує небагато концепцій для вдосконалення та професіоналізації управління партнерами на практиці, і лише кілька робіт зосереджені на екосистемах платформ IIoT. На противагу цьому, в деяких статтях емпірично детально досліджуються окремі детермінанти партнерського менеджменту. На основі цих результатів виведено концептуальну основу для організації та розмежування детермінант управління партнерами та пов'язаної з ними концепції партнерських програм.

Теоретична цінність дослідження: Дослідження робить внесок у дослідження управління партнерами в екосистемах платформ IIoT та екосистемах корпоративного програмного забезпечення, синтезуючи існуючі дослідження та підкреслюючи важливість кураторської підтримки партнерів як конкурентного важеля між екосистемами платформ, що конкурують в одному домені.

Практична цінність дослідження: Практики можуть використовувати отриману концептуальну основу для структурування діяльності з управління партнерами та прийняття більш обґрунтованих рішень на основі структурованого бачення рішень, узагальненого в концептуальній основі.

Оригінальність / Цінність дослідження: Через критичну роль взаємодоповнюючих партнерів в інноваціях на платформах IIoT концептуальна основа є важливим підґрунтям для подальших досліджень індивідуальних детермінант управління партнерами в контексті цифрових платформ.

Обмеження дослідження / Майбутні дослідження: Отримана концептуальна основа не була емпірично підтверджена. Подальші емпіричні дослідження можуть вдосконалити та розвинути концепцію в таксономію з використанням систематичних процедур.

Тип статті: Концептуальний

Ключові слова: екосистеми платформ, екосистеми платформ IIoT, управління партнерами, партнерська програма, систематичний аналіз літератури.

1. Introduction

Platform ecosystems increasingly emerge as dominant intermediating organization forms for value creation and innovation, changing the rules of value creation and competition in a growing number of domains (*Parker et al., 2017; Jacobides et al., 2018; Gawer, 2021*). An illustrative example of a platform-based ecosystem is Apple's ecosystem built on the iOS mobile operating system. External peers (i.e., third-party developers) contribute complementary applications that are compatible with the operating system (i.e., platform) and are made available to customers of iOS hardware devices (*Eaton et al., 2015; van Angeren et al., 2016*). All these actors build a platform-based ecosystem, whose added value depends on value co-creation between the platform provider and external peers (*Hein et al., 2020*).

Platform ecosystems transform the value-creation mechanisms in various domains, such as video game consoles (*Cennamo & Santalo, 2013*), automotive (*Svahn et al., 2016*) or manufacturing (*Matzner et al., 2021*). Especially in the manufacturing context, launching platform ecosystems, or entering one as a complementary partner, enables organizations to provide superior value propositions, offering digital services and software applications, such as data-driven maintenance or lean manufacturing (*Hunke et al., 2021*). Since single organizations often lack the resources and capabilities to implement data-driven services independently, digital platforms facilitate collaboration, ultimately enabling inter-organizational networks (*Porter & Heppelmann, 2014; Luz Martín-Peña et al., 2018*). In doing so, platforms also transform traditional supply chains and promote the recombination of the diverse capabilities of different organizations (*Nambisan & Sawhney, 2011; Pauli et al., 2021*). Accordingly, platforms act as a part of the digital infrastructure, optimizing collaboration and reducing transaction costs (*Selander et al., 2013; Cusumano et al., 2019*). From the technology management perspective, platforms also facilitate innovation, pooling capabilities from platform users that would not have been possible without the platform (*Eckhardt et al., 2018; Gawer, 2021*). Overall, the impact of platforms on value creation significantly changes the rules of competition in industrial practice and justifies studying the management of complementary partners as the management of partner relationships is significant for successfully establishing a platform (*Parker et al. 2017*).

Digital platforms used in industrial domains, also known as Industrial Internet of Things (IIoT) platforms, are often open to different types of third-parties, who utilize the platform functionalities and innovate upon the platform (*Arnold et al., 2022*). However, value co-creation between multiple organizations does not always happen without tensions. Existing literature reports that platform ecosystems are often characterized by agent-related problems and power asymmetries, hampering the provision of co-created services (*Eisenhardt, 1985; Cutolo & Kenney, 2021*). To overcome such tensions, platform-providing organizations in the software industry, which have been at the forefront of the digital platform emergence (*Cusumano et al., 2019*), rely on partner management. After transforming to platform ecosystems, enterprise software companies such as SAP or Salesforce implemented partner management for navigating tensions and interdependencies between the ecosystem partners (*Schreieck et al., 2019; Staub et al., 2023*).

Existing research even reasons that partner management represents a source of competitive advantage for platform organizations in markets with multiple platform providers, who compete for innovative complementors (*Cennamo, 2021; Pauli et al., 2021*).

However, research on partner management, especially concerning the specifics of industrial domains, remains in its infancy. Existing research on partner management predominantly focuses on the software industry (*Rickmann et al., 2014; van Angeren et al., 2016*). Yet, different types of partner relationships can be created based on digital industrial platforms. These can arise between industrial companies in an ecosystem or an industrial company and the platform provider. In addition, partnerships are likely to manifest both within an industry and across domains (*Petrik and Herzwurm, 2020a*).

Nevertheless, partner orchestration is recognized as a challenging responsibility of the platform provider, balancing different interests (*Hurni et al., 2021*). This is particularly true for settings, which, unlike the software industry, just start the transition from linear supply chains present in the manufacturing domain. In comparison, ecosystems are determined by coopetition between the ecosystem participants. Consequently, it is up to the platform provider to manage the resulting tensions (*Planko et al., 2019*). To achieve that, platform providers need efficient partner management and scalable mechanisms due to the multitude of partners, which is also a challenge not to limit partner engagement (*Engert et al., 2022*).

Despite its importance and complexity in enterprise settings (*Rietveld & Schilling, 2020; Staub et al., 2023; Van Vulpen et al., 2022*), such as IIoT, research on partner management is underrepresented in the scientific literature and in the platform research stream. Accordingly, relatively few explanatory models or frameworks build the outcomes in the existing literature (*Van Vulpen et al., 2022; Engert et al., 2020; Engert et al., 2021*) to support platform providers in orchestrating partners. However, existing studies, for example, are explicitly limited to partner assessment only (*Beelen et al., 2022*), or contribute only metrics (*Fotrousi et al., 2014*), missing the "big picture" of partner management. Therefore, knowledge on partner management is fragmented, especially considering the specifics of complex enterprise domains such as manufacturing (*Sarker et al., 2012; Gomes et al., 2021; Pauli et al., 2021*). However, it remains a challenge to manage partners successfully, especially for incumbent (e.g., industrial) organizations that build platforms (*Marheine & Petrik, 2021*).

Against this backdrop, this paper aims to provide a holistic and up-to-date understanding of partner management, capturing the specifics of platform-based IIoT ecosystems. To achieve this goal, the paper reports on the results of a systematic literature review. The determinants of partner management present in the literature are assembled into a conceptual framework. The purpose of the framework is discussed for future platform research and practice.

2. Theoretical Background

2.1. IIoT Platform Ecosystems

Networking of industrial equipment with information systems and business processes helps increase industrial process efficiency and release new service solutions (*Boyes et al., 2018*). Fostering technical interoperability, IIoT platforms provide a foundation for exchanging data and creating inter-organizational innovation, fostering the manifestation of dynamic networks, also known as ecosystems (*Cusumano et al., 2019; Pauli et al., 2021*). Such platforms act as middleware systems for connecting diverse industrial assets, enterprise systems, and external data sources for aggregated data analysis across organizations, offering superior outcomes (*Lasi et al., 2014; Mineraud et al., 2016*). In this context, platform organizations are responsible for ensuring sufficient platform performance to leverage the processes and solve technical issues of standardization and performance, bringing different co-creating partners (*Baldwin & Woodard, 2009; Tiwana et al., 2010; Gawer, 2014*). In doing so, platforms can generate greater value than would not be achievable for individual players without the platform (*Thomas et al., 2014*).

Therefore, IIoT platforms simultaneously act as multi-sided markets, connecting different capabilities across organizational borders. Therefore, technology management research also recognizes that digital platforms foster open innovation, which benefits from the integration of platform technologies (*Gawer, 2014; Koch & Kerschbaum, 2014; Cennamo, 2021*). IIoT platform ecosystems are complemented on multiple sides by firms such as device manufacturers, who supply platform-compatible hardware that can be integrated with the IIoT platform if complying with the platform standards. Moreover, IIoT platform ecosystems are likely to include consulting organizations collaborating with end customers, providing support with platform integration. In this way, end customers can use the IIoT platform without much IT integration effort or experience (*Hein et al., 2019*). By connecting these organizations, IIoT platform ecosystems represent a subtype of software ecosystems with a multi-actor entity that utilizes a digital industrial platform to collaborate and leverage a joint value proposition in a shared industrial domain (*Jansen et al., 2013; Pauli et al., 2021*).

Due to the indirect network effects, common interests arise between the platform and the complementors, yet the increasing influence of the complements on the platform and ecosystem value over time requires strategic considerations about managing the platform users. In the IIoT domain, most platforms are proprietary (*Gartner, 2021*). This enables platform providers to take an orchestrator role, setting rules and governing the value co-creation in the ecosystem (*Hein et al., 2020*). While the platform provider is predominantly responsible for the platform architecture and the orchestration of partner capabilities (two interdependent task areas), the complementary partners are usually in a closer relationship with the end customers. This is how a certain division of labor manifests in platform ecosystems. Empirical research indicates that sustainable ecosystem establishment can fail without careful orchestration by the platform provider (*Gawer & Cusumano, 2013*).

However, the management of multilateral partnerships with complementors, which also compete with each other within an ecosystem for access to end customers, significantly differs from traditional relationship approaches such as supply chain management. While supply chain management focuses on prices and make-or-buy negotiations, the management of partnerships with complementors is geared toward promoting their innovation performance (*Gomes et al., 2021*). In practice, these tasks are often organized through structured partner programs. They are introduced in the next section.

2.2. Partner Management in Platform Ecosystems

Embracing platform-based innovation, platform provider and their partners enter a symbiotic relationship. In partner ecosystems, the direct contact between the platform provider and the end customer shifts to the partners. Following this logic, the platform provider provides the infrastructure while complementors develop vertical solutions to address customers' problems. In this context, platform providers deploy partner programs to organize their relationships with the partners and channel all the partner-related rules. *Fig. 1* shows a general logic of partner management in platform ecosystems.

An overarching goal of partner management, defined by the existing research, is to enable productive collaboration between the platform and its partners and thus enable joint value creation. This requires carefully defining the partnership, common goals, and mutual expectations. At the start of the joint partnership, it is also crucial to ensure the partner can develop all the knowledge and skills needed to deliver complementary solutions and implement them successfully (*Avila & Terzidis, 2016*). *Guggenberger et al. (2021)* define partner management as a design principle for an IIoT platform. Its purpose is to make complement development more convenient for the partners involved over time, which also means supporting partners (*Schmidt et al., 2019*).

Different activities are known to constitute partner management. Existing research distinguishes between selecting partners and different management areas to support the management of individual partner relationships, which can be differentiated on different levels: in addition to managing individual partners, it is necessary to manage the partner program and the partner network as a whole (*Avila & Terzidi, 2016*).

Besides, partner programs may incorporate reward mechanisms (e.g., early access to new platform features) for well-performing complementors to support their engagement. This requires that partner management utilize measurable metrics (*Wareham et al., 2014; Engert et al., 2020*). At least in platform-mediated B2C domains, the relationship between platform providers and complementors can be described as a loose (i.e., arm's length) relationship. Therefore, partner programs in these domains focus on the unification and standardization of rules. For example, the platform providers Apple or Google define uniform rules for the masses of complementary app developers in their ecosystems (*Eaton et al., 2015; Cusumano, 2021*). Especially in the case of proprietary platforms, which are mostly present in the IIoT domain, platform providers also exercise control via partner programs. Existing research acknowledges the possibilities for platform providers to exercise input control on the application level (i.e., app quality control) or to define decision rights steering the centralization degree of the platform ecosystem (*Tiwana, 2014; Croitor et al., 2020*).

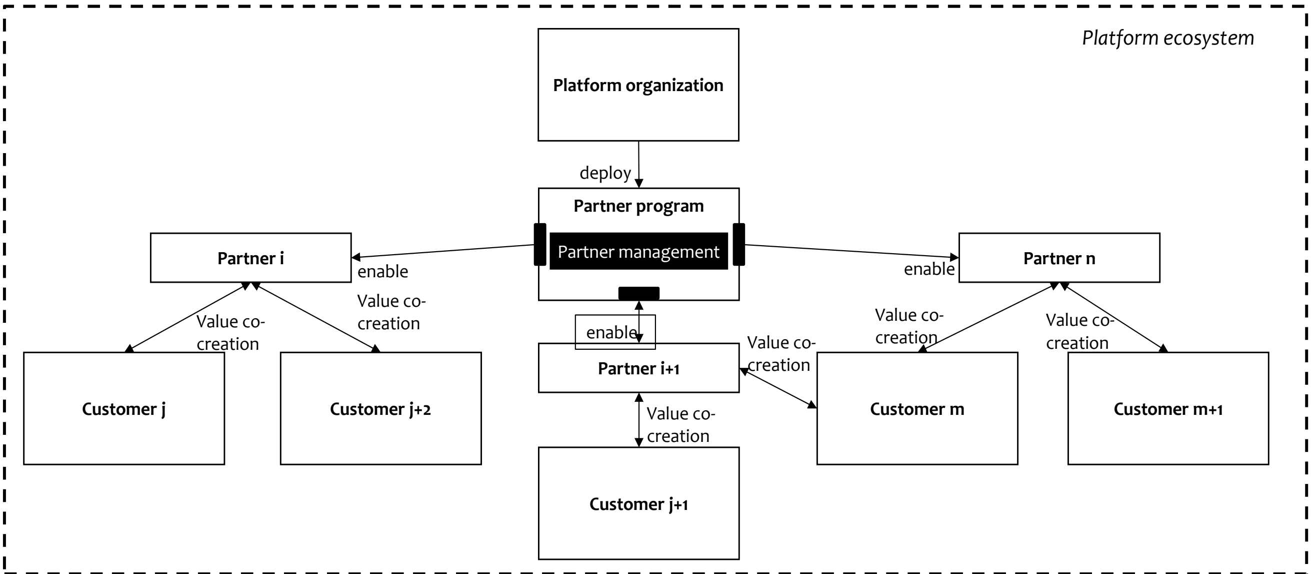

Figure 1: General logic of partner management in platform ecosystems

Source: *Research Results, 2023*

3. Research Question

Since ecosystem orchestration and partner management may overlap in objectives, and given the numerous aspects and mechanisms that can be considered for partner management, it is becoming increasingly important to know which partner management approaches have been investigated in the literature before, which of them are applicable in the enterprise context of IIoT, and what an overall concept for partner management of IIoT platforms might look like. Therefore, this paper addresses the question: *What are the relevant determinants of partner management in IIoT platform ecosystems and how can they be structured?*

4. Data and Methods

In the following, a systematic literature review based on the recommendations by *vom Brocke et al. (2009)* and *Levy & Ellis (2006)* with the scope to review and analyze the existing research on partner management in the context of IIoT platform ecosystems in order to identify existing approaches and findings on this topic and present them in a structured framework. This paper documents the following three stages of the systematic literature review process. The literature search is documented as stage one. The literature analysis is documented as stage two. During this stage, an overview of the analyzed literature is given by means of a concept matrix according to the recommendation of *Webster & Watson (2002)*. In contrast to the process defined by *Vom Brocke et al. (2009)*, stage three does not set a research agenda but presents a conceptual framework.

To define and present the scope of our literature mapping study, we rely on the taxonomy of *Cooper (1988)*, which consists of the categories (1) Focus; (2) Goal; (3) Perspective; (4) Coverage; (5) Organization; (6) Audience. Our study focuses on (1) research outcomes, practices, and applications. The (2) goal of the research is the integration of the research topics on partner management applied in the context of IIoT platform ecosystems. A neutral representation was chosen (3) with the aim to achieve (4) a central coverage without expecting exhaustivity. The (5) organization of the included articles is conceptual. The (6) target audience consists of information systems scholars, who research relationship management and orchestration in platform ecosystems, and the practitioners involved in partner management.

The main goal is to bring together existing findings and identify tension areas. As a result of the literature analysis, the emerging framework is intended to form the starting point for classifying further research into partner management in the context of IIoT platforms.

The first step was a keyword search in scientific databases Ebscohost Business Source Premier, JSTOR, ScienceDirect, IEEE Xplore, AISeL, SpringerLink and Google Scholar. The search terms "IIoT platform" were used in combination with "partner management" or "complementor management". Since searching for alternative phrases such as "industrial internet of things platform" or "industrial digital platform" did not yield any additional results, these search queries were later abandoned. Google Scholar was used as a meta database in the end of the search process to find relevant papers that were not discovered during the prior search. Considering the exclusion criteria, the search was limited to English-language literature and peer-reviewed academic articles. Accordingly, master theses (i.e., found via Google Scholar) were excluded from the search.

The results found in the databases were analyzed for their relevance to partner management in IIoT platforms based on title and abstract, and only relevant articles were included in the literature pool.

Literature examining enterprise software platforms was also included in the literature sample since these types of platforms is also used in B2B domains. In addition, enterprise software platforms are similar to IIoT platforms regarding the importance of partner requirements to join a platform ecosystem (e.g., due to the criticality of business data later processed on the platform). This decision to extend the literature search was made during the reading of papers and the backward search of additional sources, as they provided reasonable and adaptable knowledge but were dedicated to enterprise software, occasionally mentioning Internet of Things. For this purpose, an additional search was conducted based on the combination of terms "platform" and "partner program". In doing so, it was possible to include articles that do not explicitly focus on the IIoT domain yet posit relevant knowledge about partner management and the design of partner programs that may apply to IIoT. However, the search string using the term "platform" was kept rather open and the articles on enterprise software platforms were screened based on abstract. This resulted in twenty-one articles that were not IIoT-specific but related to enterprise software platforms contributing a significant amount of knowledge to the derived framework and highlighting the infant state of research in the IIoT context. The articles found in multiple databases were also removed. *Tab. 1* gives an overview of the literature search process. In case of a very large number of hits (i.e., returned by the Jstor database), it was decided to define a boundary for the number of considered papers. Therefore, the effort of literature analysis was bounded by considering only the first 300 database hits. This decision was met during the analysis of the papers returned by the database and is based on the observed decreasing relevance of the papers on the research topic, ensuring a theoretical saturation on the database level with relevant publications no longer appearing.

Table 1: Overview of the search process

Related concepts				
	(IIoT platform) AND (partner management) OR (complementor management)		(platform) AND (partner program)	
Database	**Total**	**Relevant**	**Total**	**Relevant**
Ebscohost	2	0	860	1
Jstor	90	0	36359*	3
ScienceDirect	0	0	157	0
IEEE Xplore	1	0	163	0
AiSeL	80	5	7093	7
SpringerLink	39	3	199	0
Google Scholar	2	1	461	10

See the full paper list with the related databases in the appendix

Note: **only 300 database hits were analysed due to the decreasing relevance of the returned hits*

Source: *Research Results, 2023*

5. Results

5.1. Synthesis of the Scientific Work on Partner Management in IIoT Platform Ecosystems

The small number of newly identified articles indicates that all relevant articles were identified. In total, thirty relevant articles were identified that were published between 2009 and 2022. Seventeen identified articles were published in scientific journals, and fourteen were conference papers. The relatively high number of conference articles results from the equal ranking of conference proceedings as *VHB (2015)* in the discipline of information systems, in which a significant proportion of platform research took place. Furthermore, the distribution reflects both the timeliness of the topic and highlights the previously mentioned thin state of research to date. The concept matrix in *Tab. 2* shows the concepts from the literature sample, which are presented below.

Table 2: Conceptual research overview on partner management suitable for IIoT

Authors / Related aspects	Discovered concepts													
	Result type				Insights on determinants and their management									Other
	Models and frameworks	Approach	Metrics	Tool Support	Selection	Enablement	Engagement	Evaluation	Partner lifecycle	Openness and standardization	Formal control	Values and communication	Partner variety	Partner program design
Avila and Terzidis (2016)	X						X							
Beelen et al. (2022)		X			X			X						
Benz et al. (2021)							X							
Ceccagnoli et al. (2012)							X							
Engert et al. (2020)			X					X						X
Engert et al. (2021)				X										
Engert et al. (2022)						X	X	X		X				
Foerderer et al. (2017)						X				X				
Guggenberger et al. (2021)										X				
Hodapp et al. (2021)											X			
Huang et al. (2013)							X							X
Huber et al. (2017)										X	X	X		
Hurni et al. (2020)							X				X	X		
Mei et al. (2021)														X
Jonas et al. (2018)							X							
Kude et al. (2019)										X				
Marheine et al. (2021a)						X								
Marheine et al. (2021b)											X			
Pauli et al. (2020)						X							X	
Petrik and Herzwurm (2020a)													X	
Petrik and Herzwurm (2020b)						X			X					
Rickmann et al. (2014)	X				X		X							
Schermuly et al. (2019)										X				
Schreieck et al. (2017)				X						X	X		X	
Schreieck et al. (2019)									X					
Schmidt et al. (2019)														
Van Vulpen et al. (2022)	X					X								
Wareham et al. (2014)								X		X	X			X
Wei et al. (2020)		X			X			X						
West and Wood (2014)													X	X

Source: *Research Results, 2023*

The sample containing relevant research results on partner management in IIoT can be roughly clustered based on the specific result types or the determinants on which specific insights are gained. In addition, some articles contain definitions and conceptualizations of the partner management construct. They are supported by insights considering the enablers of partner management, the goals of partners, partner program design options, and case studies of how non-platform companies are becoming platform providers in the IIoT, forcing them to launch partner programs.

Result types: Existing research presents several frameworks and models to improve the overall understanding of partner management. To understand partner management, *Avila & Terzidis (2016)* develop a conceptual framework of related factors and influences. *Rickmann et al. (2014)* present a framework by driving the grounded theory approach that combines a concept and a process view. While the concept view extends the partner management by considering partner goals, enablers, and instruments to drive partner management effectively, the process view increases the awareness of a partner relationship lifecycle. *Van Vulpen et al. (2022)* also present similar fields of action in a model without differentiating between the two views. However, the model proposed by *Van Vulpen et al. (2022)* also incorporates partner goals and ecosystem enablers. To support a structured partner management approach during the lifecycle of the partnership, *Engert et al. (2020)* introduce several metrics to evaluate partners and develop a prototypical tool for partner managers (*Engert et al., 2021*).

Selection: When following the process of partner selection, the state of research offers two approaches to support the partner evaluation (*Beelen et al., 2022; Wei et al., 2020*). *Wei et al. (2020)* propose a criteria-based evaluation of partners, focused at potential partners' basic operational capabilities, platform compatibility, and collaborative risk. On a more detailed level, *Wei et al. (2020)* suggest evaluating operational metrics based on consolidated financial statements, the alignment of long-term goals, compatibility of technologies used, collaborative willingness and attitude, and past behaviors in collaborations. These criteria can be used to ensure the compatibility of potential partners with that of the platform-related demands, for example, in terms of compatibility of goals and technologies. This evaluation represents only the first phase in a two-stage partner selection process. The partners evaluated as suitable are added to a pool of potential partners. Access to this pool should not be too strictly limited to get a variety of different partners. In the second phase, partners will be targeted for integrating and developing customer solutions from the partner pool created in the first phase. The first step in this process is the precise definition of customer requirements. These requirements are then translated into a technical design and tasks to be performed. This is best done by dividing the overall project into modules. After the release to the partner pool, the partners perform a self-evaluation to what extent they have the knowledge and resources to provide modules. Then the platform owner re-evaluates the candidates. This is done based on the partners' individual characteristics (e.g., technological, and financial capabilities) and the characteristics of the partnership interaction (e.g., complementarity and future viability). Obviously, third-party organizations that best fit the requirements are finally selected as partners (*Wei et al., 2020*). *Beelen et al. (2022)* propose systematically detecting missing capabilities in the ecosystem to search for partners and proactively approach the innovative ones. After the partner selection, partner assistance, communication capabilities, and evaluation of partners are critical (*Avila & Terzidis, 2016*).

Enablement: A significant amount of prior research is dedicated to the in-depth research of phenomena of specific partner management determinants and trade-offs that a platform provider has to balance. A critical determinant of partner management is the enablement of partners to utilize the platform that becomes relevant. In partner management, it is important to onboard partners as an indirect sales channel, align the platform core with the partner requirements, and manage the balance in the partner portfolio. The portfolio is associated with the necessity to select innovative partners, ensuring different strategic and organizational fits between the platform organization and the potential partners. After the partner selection, onboarding procedures are important. Trust building and support from the platform provider are important during onboarding (*Avila & Terzidis, 2016*). *Schreieck et al. (2017)* mention the necessity for the platform provider to share boundary resources with the partners that range between interfaces (e.g., APIs), development tools (e.g., SDKs), and support documentation that are necessary for partners to innovate. Furthermore, it is also a meaningful task within partner management to ensure that partners are satisfied with the boundary resources provided, as these are needed for complement development and, therefore, to monitor their quality (*Petrik and Herzwurm, 2020b*). *Engert et al. (2022)* identify two ways the platform provider can generate engagement with boundary resources by recognizing that there are not only standardized but also individual boundary resources. *Foerderer et al. (2017)* examine three different types of knowledge asymmetries between the platform owner and its partners in the context of partner management and map three solution approaches to the different knowledge asymmetries. Namely, both the functional scope of the platform and the design of the platform interfaces require platforms to be comprehensively understood by partners. Here, partners depend on the platform provider to provide knowledge about the platform functionalities. A wide functional scope of the platform or the provision of highly specific interfaces (i.e., neglecting existing standards) increases the knowledge inequality between the platform owners and its partners. Whereby syntactic asymmetries refer to a lack of common terminology, semantic ones to a lack of common understanding, and pragmatic ones to a lack of common motivation for knowledge exchange and integration. Platform providers can use standardized broadcasting for syntactic knowledge asymmetries as part of partner management, and brokering can be used to overcome semantic asymmetries. Bridging is used for pragmatic knowledge asymmetries. In their conceptual framework, *Rickmann et al. (2014)* see the sharing of resources as an enabler of partner management. *Van Vulpen et al. (2022)* also propose a partner management framework comprising partner management areas, partner goals, and ecosystem enablers. Partner goals equal the objective of partners to utilize a platform. Ecosystem enablers can support them. However, *Van Vulpen et al. (2022)* develop a broad view of ecosystem enablers, going beyond the resource and knowledge aspects. In particular, the authors see trust, the leadership of the platform provider, alignment capabilities, and communication as equivalent enablers. *Pauli et al. (2020)* elaborate on the specifics of the IIoT domain, revealing that certain partner types, who did not collaborate on shared propositions in the past, also need to be enabled in terms of collaboration.

Engagement: Creating shared value can also benefit from the commitment of partners. Commitment can be measured and thus managed. Engagement in this context comprises, on the one hand, the fundamental willingness of an ecosystem actor to invest resources in interaction with other actors and, on the other hand, the extent to which this actually happens. Partner engagement behavior describes the extent to which an actor's counterpart exhibits engaged behavior in the context of joint value-creation activities. *Benz et al. (2021)* continue to develop an understanding of partner engagement in the context of an IIoT platform and have so far identified the two concepts of partner engagement behavior and value realization. The concept of value realization refers to the level of benefit that a partner believes they will realize through their engagement in a platform ecosystem. Furthermore, it makes sense to consider engagement on an individual level. *Jonas et al. (2018)* identify nine factors that influence individual stakeholder engagement in inter-organizational innovation ecosystems. These can be divided into cognitive, emotional, and behavioral factors. In addition, it can be seen that their hierarchy level influences the commitment of stakeholders. While commitment tends to be low at the project manager level, higher commitment can be found at the top and operational levels. A common goal among all participants and spatial proximity to each other are listed as the main factors for high commitment. Institutional arrangements to create a common understanding of communicating and working across organizational boundaries also increase stakeholder engagement. It can be concluded that engagement is influenced to a large extent by interaction and communication (*Jonas et al., 2018*). *Engert et al. (2022)* see sources of complementor or partner engagement in fulfilling the partner goals. The authors define platform alignment and driving innovation and success. Partners will likely ensure alignment with the platform's technical or legal frameworks and enhance their product innovation and sales due to platform technologies and access to a platform-related customer base. *Ceccagnoli et al. (2012)* offer further empirical evidence that partners join a platform ecosystem to increase sales or support an initial public offering (IPO). Moreover, *Guggenberger et al. (2021)* identify key requirements that various stakeholders place on iIoT platforms. It is therefore also a task of partner management to channel the heterogeneous requirements from complementors regarding the platform and to incorporate them into further development. Examples of complementor requirements include support services and gain-sharing approaches. *Huang et al. (2013)* see functioning intellectual property rights set of rules as crucial for complementor engagement and define it as one of the partner goals. *Rickmann et al. (2014)* complement the financial gains by distinguishing between customer access, hope to meet better customer demands, integrating own products with the platform, and expanding their business as partner goals. *Marheine et al. (2021a)* drive forward the understanding of partner benefits from general enterprise software to IIoT, distinguishing between technological, knowledge, and financial gains on the side of partners to mitigate uncertainties related to these three dimensions of partner benefits. The solution concepts defined by *Foerderer et al. (2017)* are also intertwined with the knowledge-related partner goals. However, it must be considered that potential partners in the IIoT often also want individual support, and platform providers are more sensitive to this compared to B2C platforms *(Schermuly et al., 2019)*.

Evaluation: Since partner engagement and the relationship with the platform provider is unstable, partner engagement evaluation is the key to an effective partner program (*Avila & Terzidis, 2016; Engert et al., 2020)* to steer further development of a partnership in the right direction or to end it if necessary. Evaluation of partner engagement is the key to an effective partner program. The evaluation criteria against which partners are assessed and assigned levels in the partner program depend on their role in the platform ecosystem and their partner level on the one hand and vary from platform to platform on the other. The metrics for this vary between general and specific criteria for sales and development partners. The general criteria include those that support the development of close collaboration between the platform and the partner. This includes joint business planning with partners at higher partner levels. The number and positions of staff assigned with tasks to coordinate partnership efforts is also a common criterion. Partners at the upper levels in the partner program are also expected to designate an executive-level sponsor. Exclusivity requirements that prohibit working with other platforms also occur (*Engert et al., 2020*). *Engert et al. (2020*) also introduce several metrics to measure partners' expertise, performance, and marketing efforts. *Wareham et al. (2014*) introduce different partner levels, ranging between a simple registration and a maximum commitment, indicated by partners' personal certification and demonstration of competency. *Engert et al. (2021)* also present a prototypical instantiation of a partner management tool to manage all this. In addition, *Schreieck et al. (2019*) shed light on the changing nature of an existing partner relationship since neither the partners nor the platform providers remain stable. Particularly if platform providers change, partner management gets tasked with accompanying change management for partners and explaining what these changes mean for future collaboration. In addition, careful observation, and analysis of the reasons for negative partners' reactions on the platform evolution can reveal the potential for improvement of the platform and monitor partner engagement in the first place (*Schreieck et al., 2019; Engert et al., 2022*). In particular, the effects achieved with the provision of boundary resources may change during the lifecycle of the partnership (*Petrik & Herzwurm, 2020b*).

Openness: Among the identified trade-offs, the degree of openness (i.e., selective partner choice) and the coexistence of horizontal (generic) and vertical (specific) complements can be derived as two essential determinants of partner management (*Schreieck et al., 2017; Schermuly et al., 2019*). The platform owner is faced with the challenge of implementing all these goals in a way that enables the simultaneous management of a large number of partners without ignoring the needs of the individual partners, thus enabling the most productive collaboration possible. Two archetypes of partnership relationships can be identified depending on the degree of standardization of the partnership. On the one hand, closer dyadic relationships, which are more like traditional, non-platform-based partnerships, and on the other hand, "arm's length" partnerships, which describe a standardized, rule-based, and impersonal type of partner management. Depending on the intended closeness of the partnership, there are different requirements for the partner managers who shape it. Arm's length relationship management primarily requires partner program competencies as well as some relationship and network competencies. These competencies form the basis of dyadic relationship management, which requires additional relationship, network, and situational mindfulness competencies (*Kude et al., 2019*). Nevertheless, there are differences in partner management in the extent to which partner managers adhere to the rules of the partner program or go the extra mile and thus selectively favor some partners over others. *Huber et al. (2017*) look at the extent to which platforms allow deviations from their established rules and what effects rule adjustments have. It is shown that standardized management can be regarded as the normal state within the framework of which the rules are strictly followed. It leads to low management costs, but the full value creation potential cannot be captured. Rule adherence can be communicated on the part of the platform partnership manager with or without emphasizing platform values such as fairness, equality, and integrity. This has a great impact on the relationship with the platform partners. Emphasizing the values signals the trustworthiness and reliability of the platform and can build relationship capital. If this communication is missing, the rigid insistence on rules will be understood as not being in the spirit of a true partnership. Besides, a critical task in partner management in the context of IIoT is aligning all partners to certain standards and the standardization of the technologies supported by the platform in general (*Schreieck et al., 2017; Guggenberger et al., 2021*).

Formal control: Formal control is also present in IIoT platform ecosystems (*Schreieck et al., 2017*). However, formal input or output control is only described for app marketplaces. Therefore, it does not affect the machinery data streamed to the platform. Besides, trust is mentioned as a relevant mechanism of partner management (*Schreieck et al., 2017*). In IIoT it was noticed to be signaled with reference cases and customers. Rules form the basis for actions in the ecosystem, but they provide certain leeway, which is implemented differently by the acting persons in different contexts. Rule appropriateness is perceived differently by each partner, depending on the partners' situation. *Hurni et al. (2020)* consider the impact of situational deviations from standard rule-based partner management in favor of a closer, dyadic partner relationship on partner commitment. In doing so, they establish the concept of rule appropriateness. This describes the extent to which partners perceive the rules as safeguarding the interests of the platform owner and their own interests. To do this, platform rules must protect partners' resources, prevent inappropriate behavior of the platform owner, and facilitate beneficial outcomes from the partnership. It turns out that partner commitment increases with rule appropriateness. The strength of this effect depends on how flexible and benevolent the rules are implemented in practice (*Hurni et al., 2020*).

Values and communication: Furthermore, the cases in the sample describe how formal shared value can support rules. To align partner networks based on the shared value, platform providers require communication capabilities. *Hodapp et al. (2022*) also highlight how important communication is to get a shared understanding of certain goals or even the concept of the platform ecosystem between the platform provider and the partners eager to join. *Marheine et al. (2021b*) expand on this finding using the example of another incumbent company and present this as a challenge that must be overcome to create a shared understanding of a strategy. Communication is thus intertwined with the shared values of a partner ecosystem.

Partner variety: *Petrik and Herzwurm (2020a*) and *Pauli et al. (2020*) identify inevitable tensions in leveraging the partners to co-create on the platform. First, the partner variety in IIoT is challenging, and a platform must be able to offer and communicate a superior value to the partners, as industrial firms may have collaborated in the past before the shift on the platform. Hence, partner management should consider the legacy partnerships and develop approaches to convince them to join the ecosystem, extending their partnership or migrating it to the platform ecosystem. *Schreieck et al. (2017*) also differentiate between different partner types in IIoT platform ecosystems, explicitly distinguishing between infrastructure providers, device integrators, and complementors. One can deduce that IIoT platform ecosystems do not only rely on complementors, but also include strategic partnerships, and bridging the gap between partner types is a balancing act for partner management. *Pauli et al. (2020*) similarly see the partner variety as an additional tension for successful partner management. Although outside of the IIoT domain, *West & Wood (2014)* offer rich empirical evidence to outline the tension between different partner roles based on the case of Symbian, differentiating between phone manufacturers and software developing organizations, technology providers, and each of them was granted a stand-alone partner program.

Partner program design: Partner programs build a common manifestation of a catalog of rules for a platform's efficient and scalable partner management, especially if arm's length partner management is the goal. In that case, scalable, rule-based mechanisms should be applied either equally to all partners or a specific partner category. When formulating these rules, it is essential for platform providers to standardize the efficient management of large partner networks. In addition, platform providers are advised to integrate partner management into the organizational structure of the platform from the very beginning (*Avila & Terzidis, 2016*). *Engert et al. (2020*) define four general characteristics of partner programs. The most common are three- or four-level systems, with the lowest level being a basic level with minimal requirements for newly registered partners. Above this are two or three levels with similar activities but increasing performance requirements. In addition to the partner-level classifications, partner programs distinguish partners according to their role within the ecosystem. The programs examined in the sample distinguish between sales and implementation partners and development partners. On the one hand, sales and implementation partners are technical consultancies that take care of sales, implementation, and customization of digital services and applications offered based on a platform. On the other hand, development partners create complementary applications and services, which they make available via the platform. In addition to these two roles, infrastructure providers and device integrators are also identified as possible partner types. Furthermore, multi-tier partner programs build another option to differentiate partners by introducing different levels (*Wareham et al., 2014*). Certain partner levels are used in IIoT partner programs to provide partners with exclusive information on platform development and new collaboration possibilities within the ecosystem (*Petrik & Herzwurm, 2020b*). In addition, partner programs can use motivational mechanisms (e.g., "best partner" awards) to support partner engagement (*Mei et al., 2021*) and define rulesets for intellectual property rights (*Huang et al., 2013*). Another design dimension is the possibility of installing different partner programs differing in their standardization effort to respond to different or even conflicting needs of different partner types, although it requires specific organizational capabilities and additional financial efforts (*West & Wood, 2014*).

5.2. Conceptual Framework of Partner Management in IIoT Platform Ecosystems

This section proposes a conceptual framework, interpreting the existing knowledge on partner management to provide prescriptive knowledge for platform providers. Thus, it helps to structure the different determinants of partner management from the literature sample (i.e., partner programs and partner management or the different interpretations of determinants in the papers reviewed), which are closely related and may be difficult to distinguish for scholars and practitioners. *Fig. 2* illustrates the conceptual framework.

The framework utilizes a process-oriented view of partner management and puts the partner management stages into a sequence of process steps: (1) partner selection; (2) partner enablement; (3) partner engagement; (4) partner evaluation. Additional building blocks are assigned to each step, representing its aspects or objectives. In addition, the four steps are complemented by the platform providers' general decisions derived from the literature.

The framework also includes the identified determinants of partner programs, which help to realize partner management in practice. The overview of the overarching decision determinants can help platform providers to set a fundamental direction for the management of their partner ecosystem, while the different objectives and tasks could help platform organizations in setting up new microfoundations for successful support of value co-creation through partner management. In addition, the framework considers several designable components for platform providers' self-assessment during the partner program establishment. Overall, the discovered determinants can support platform providers in developing capabilities for the identified process steps of partner management or designing the partner program.

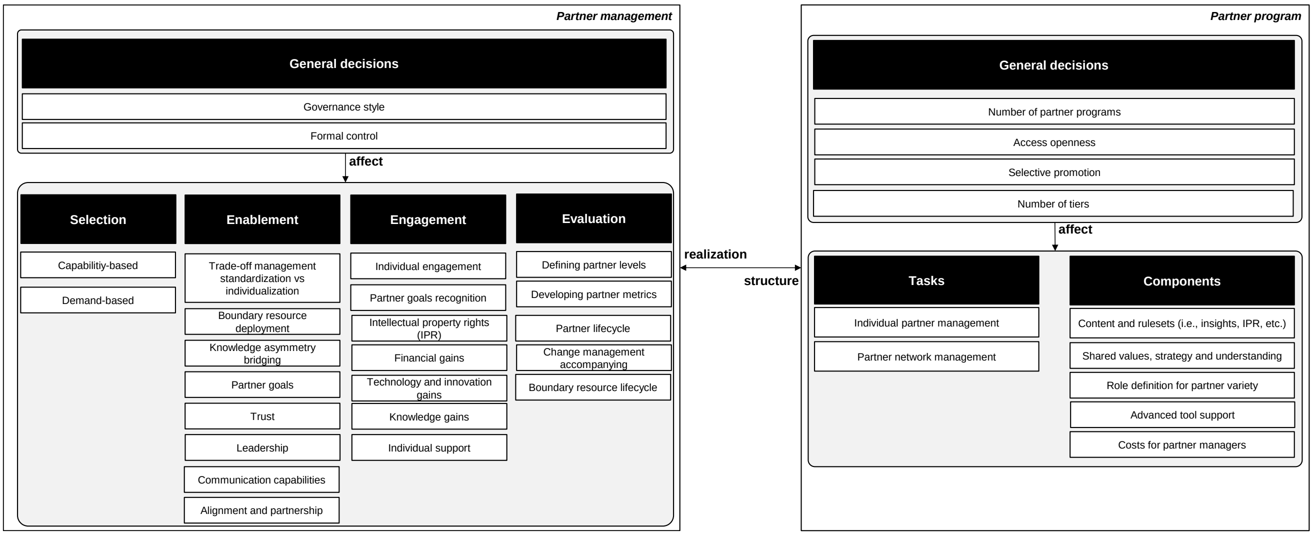

Figure 2: Conceptual framework of partner management

Source: *Research Results, 2023*

6. Discussion

The purpose of this paper was to review the existing literature and identify the relevant determinants of partner management suitable for platform ecosystems in the IIoT domain. The determinants are used to advance prescriptive knowledge about partner management in IIoT platform ecosystems and build a framework. The framework development was predominantly motivated by the current state of research on partner management, which offers only a few frameworks to guide partner management (*Rickmann et al., 2014; Van Vulpen et al., 2022*).

The framework reduces the messiness in the multiplicity of the identified determinants and increases the tangibility of partner management.

Compared to the work published by *Van Vulpen et al. (2022*), the framework integrates a process view of the individual phases. Compared to *Rickmann et al. (2014*), the process chain is extended by various determinants from newer research on partner management. In comparison to the two frameworks, a conscious distinction is also made between partner management and the partner program for its implementation, following *Avila & Terzidis*

(2016). The integration of the determinants for the partner program design is also new compared to the other two frameworks.

The paper contributes to the research stream on platform competition (*Cennamo, 2021*). While prior work already recognized several strategies to sustain competition between multiple platform providers in a market (*Rietveld & Schilling, 2020*), such as forking of platform functionalities or the boundary resources of a platform (*Karhu et al., 2018*), or performing envelopment of the platform user base (*Eisenmann, 2011*), this paper adds to the perspective of using and supporting complementors as a competitive lever. The paper complements the perspective by structuring the body of knowledge on partner management to support future empirical research on complementor-oriented competitive moves of platform providers through their partner programs.

The results can be used for multiple future research directions. On the one hand, the conceptual framework can serve as a theoretical foundation for further empirical research on the effectiveness of partner management strategies. On the other hand, the theories that have not been used so far in the context of ecosystem partner management can support the empirical research. Such theories, for example, as the principal-agent theory (*Bergen et al., 1992*) or the social exchange theory (*Cropanzano et al., 2005*) explain certain aspects of relationships between multiple actors, and could provide new explanations about driving successful partner management as a platform provider. Besides, applying situational method engineering could help to engineer new methodological approaches (*Henderson-Sellers & Ralyté, 2010*) to support the individual steps of partner management (e.g., systematic selection and evaluation of partners) from the platform provider perspective.

As with any research work, the conducted study is affected by limitations. First, the data collection of any literature review is open to interpretation. Therefore, other researchers are likely to include other keywords in the search string. For instance, the final sample did not cover the existing open innovation research well due to the keyword selection, although platform research originated from the research on open innovation. Particularly, open innovation can be supported through the interfaces of digital platforms or specific platforms providers' strategies to distribute the locus of innovation between multiple ecosystem actors (*Eckhardt et al., 2018; Cenamor & Frishammar, 2021*). However, according to our sample, open innovation is merely mentioned as one of the partner management goals. Thus, even if partner management can provide organizational support for open innovation, it is not well represented within the examined literature sample. A possible explanation for this is platform providers' use of proprietary strategies in the context of IIoT (*Gartner, 2021*). Consequently, future research could address this phenomenon and focus on concrete organizational decisions and partner program design aspects or tasks that can evidently support open innovation, and thus extend the research result of this study.

Second, since the study was conducted by one researcher, the interpretation of the sample is subject to the author's perspective on the topic, implying a researcher bias. Nevertheless, the author carefully reflected on the literature scope using the taxonomy proposed by *Cooper (1988*). In addition, the identified determinants became the subject of iterative reflection, so a variety of partner management determinants that can be applied in enterprise platform ecosystems were discovered.

Third, the conceptual framework rests solely on the data from the literature. Despite a significant number of conference papers, most of which present more up-to-date data than journal articles, published scientific results usually lag behind the practice. Therefore, a functional analysis of the existing partner programs and expansion of the study in a multivocal literature review (i.e., by adding gray literature to the sample) could also be a future research possibility. Furthermore, empirical validation of the framework has not been carried out and would be an essential follow-up step in the research project. This is particularly necessary since certain determinants originate from research on enterprise software and have only been transferred to IIoT platforms through the researcher's interpretation. Besides, the usefulness of the framework in practical application is unknown. To mitigate this limitation, further validation through expert interviews or group Delphi studies to reach a consensus on the framework is required in the future. Second, despite conducting an additional search on partner management in enterprise software, the selection of search terms does not include such terms as manufacturing ecosystems or digital business ecosystems since only nine IIoT-specific papers were included in the sample. Including these search queries would potentially lead to additional literature on industrial actors and add further determinants or insights to the identified determinants. After all, industrial firms, among all possible partner types, have the greatest difficulties in shifting from rigid supply chains into more flexible partner management structures (*Suuronen et al., 2022*). Therefore, complete coverage of the determinants cannot be ensured and requires additional research.

Collecting empirical data on the framework would also make it possible to create a taxonomy from the framework. A taxonomy is defined as a set of dimensions, each consisting of multiple characteristics that can be exclusive or not. To derive a taxonomy, a well-adapted structured approach developed by *Nickerson et al. (2013)* and updated by *Kundisch et al. (2021*) requires at least one additional empirical-to-conceptual design cycle to complement the knowledge of a specific object from the literature and refine the taxonomy. In addition, the suitability of the taxonomy in contributing to the defined objective should be demonstrated by applying it to empirical cases.

Lastly, since the IIoT platforms and the related partner programs develop dynamically, the extension of the framework must be considered. However, the proposed framework is open for future extensions, abstractions, and adoptions to other platform-mediated domains.

7. Conclusion

Despite the increasing relevance of platform ecosystems in various domains, a comprehensive understanding of partner management is still largely missing, although it is necessary for professionalizing ecosystem development. This paper proposes a conceptual partner management framework suitable for but not entirely restricted to IIoT platform ecosystems derived from a systematic literature review on partner management in IIoT and enterprise software. Based on a set of thirty papers framework includes eight determinants and thirty-four aspects assigned to the determinants. This work establishes a foundation for future contributions to partner management in IIoT platform ecosystems by synthesizing the existing knowledge. Future research on partner management or platform competition via partners can build on the identified determinants and the framework and position their research work more precisely. Besides, the insights offered by this study increase the platform and ecosystem researchers' understanding of the existing determinants within partner management and its current state of research to isolate each for future research studies. Partner managers in practice may benefit from the framework to structure and professionalize their partner programs and partner management approaches to earn a competitive advantage (*Cennamo, 2021*) in the intra-platform competition for innovative complementary partners, and the industrial domain, in particular, can use the framework to build partner programs for digital and data-driven servitization (*Lasi et al., 2014*).

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9. Competing interests

The author declares that he has no competing interests.

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Appendix

Number	Authors	Titles	Database
1	*Avila and Terzidis (2016)*	Management of Partner Ecosystems in the Enterprise Software Industry	Google Scholar
2	*Beelen et al. (2022)*	Are you of value to me? A partner selection reference method for software ecosystem orchestrators	Google Scholar
3	*Benz et al. (2021)*	Co-Creating Value in B2B Platform Ecosystems – Towards a Deeper Understanding of the Emergence and Nature of Actor Engagement	AiSeL
4	*Ceccagnoli et al. (2012)*	Cocreation of Value in a Platform Ecosystem: The Case of Enterprise Software	Jstor
5	*Engert et al. (2020)*	Partner Programs and Complementor Assessment in Platform Ecosystems: A Multiple-Case Study	AiSeL
6	*Engert et al. (2021)*	Enabling Partner Management in Enterprise Platform Ecosystems - A Design Science Research Study	AiSeL
7	*Engert et al. (2022)*	The Engagement of Complementors and the Role of Platform Boundary Resources in e-Commerce Platform Ecosystems	SpringerLink
8	*Foerderer et al. (2017)*	Knowledge boundaries in enterprise software platform development: Antecedents and consequences for platform governance	Google Scholar
9	*Guggenberger et al. (2021)*	How to Design IIoT-Platforms your Partners are Eager to Join: Learnings from an Emerging Ecosystem	SpringerLink
10	*Hodapp et al. (2021)*	Key Lessons from Bosch for Incumbent Firms Entering the Platform Economy	AiSeL
11	*Huang et al. (2013)*	Appropriability Mechanisms and the Platform Partnership Decision: Evidence from Enterprise Software	Jstor
12	*Huber et al. (2017)*	Governance Practices in Platform Ecosystems: Navigating Tensions Between Cocreated Value and Governance Costs	Google Scholar
13	*Hurni et al. (2020)*	Complementor dedication in platform ecosystems: rule adequacy and the moderating role of flexible and benevolent practices	Google Scholar
14	*Mei et al. (2021)*	Governance mechanisms implementation in the evolution of digital platforms: a case study of the Internet of Things platform	Ebscohost
15	*Jonas et al. (2018)*	Stakeholder engagement in intra- and inter-organizational innovation Exploring antecedents of engagement in service ecosystems	Google Scholar
16	*Kude et al. (2019)*	Successfully governing software ecosystems: Competence profiles of partnership managers	Google Scholar
17	*Marheine et al. (2021a)*	From Suppliers to Complementors: Motivational Factors for Joining Industrial Internet of Things Platform Ecosystems	AiSeL
18	*Marheine et al. (2021b)*	Challenges and Opportunities for Industry Incumbents in Enterprise IoT Initiative	AiSeL
19	*Pauli et al. (2020)*	Leveraging Industrial IoT Platform Ecosystems: Insights from the Complementors' Perspective	AiSeL
20	*Petrik and Herzwurm (2020a)*	Towards the iIoT Ecosystem Development - Understanding the Stakeholder Perspective	AiSeL
21	*Petrik and Herzwurm (2020b)*	Boundary Resources for IIoT Platforms – a Complementor Satisfaction Study	AiSeL
22	*Rickmann et al. (2014)*	Software Ecosystem Orchestration: The Perspective of Complementors	AiSeL
23	*Schermuly et al. (2019)*	Developing an Industrial IoT Platform – Trade-off between Horizontal and Vertical Approaches	AiSeL
24	*Schreieck et al. (2017)*	Governing Platforms in the Internet of Things	SpringerLink
25	*Schreieck et al. (2019)*	Shifting to the Cloud-How SAP's Partners Cope with the Change	AiSeL
26	*Schmidt et al. (2019)*	Kick-Start for Connectivity - How to Implement Digital Platforms Successfully in Industry 4.0	Google Scholar
27	*Van Vulpen et al. (2022)*	The Orchestrator's Partner Management Framework for Software Ecosystems	Google Scholar
28	*Wareham et al. (2014)*	Technology Ecosystem Governance	Jstor
29	*Wei et al. (2020)*	A conceptual framework of two-stage partner selection in platform-based innovation ecosystems for servitization	Google Scholar
30	*West and Wood (2014)*	Evolving an Open Ecosystem: The Rise and Fall of the Symbian Platform	Google Scholar

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