Technische Universität München
TUM School of Computation, Information and Technology

Managing Complementor Engagement in Digital Platform Ecosystems

Martin Engert

Vollständiger Abdruck der von der TUM School of Computation, Information and Technology der Technischen Universität München zur Erlangung eines

Doktors der Naturwissenschaften (Dr. rer. nat.)

genehmigten Dissertation.

Vorsitz: Prof. Dr. Florian Matthes

Prüfer*innen der Dissertation:

1. Prof. Dr. Helmut Krcmar
2. Prof. Dr. Jens Förderer

Die Dissertation wurde am 23.09.2022 bei der Technischen Universität München eingereicht und durch die TUM School of Computation, Information and Technology am 24.04.2023 angenommen.

Preface

With the finalization of this thesis, an exciting and challenging journey comes to an end. Successfully arriving at this point would not have been possible without many's genuine and continued support – for each of which I am entirely grateful.

I express my sincere gratitude to my doctoral supervisor Prof. Dr. Helmut Krcmar, for lively discussions, honest feedback, and the chance to shape this dissertation according to my interests. You provided the necessary guidance, structures, and a network of practitioners and academics that made my dissertation possible. This engaging environment gave me insights into various topics and projects and allowed me to forge my personal network and pursue international collaborations.

My dissertation has greatly benefitted from the supervision and sparring with Dr. Matthias Pfaff and Dr. Andreas Hein. You have supported this journey along with two very different phases of this project, and I am thankful for the trust, encouragement, feedback, and motivation that you provided. Moreover, I would like to thank Prof. Jason Thatcher and Prof. Likoebe Maruping for being fantastic role models, many inspiring discussions, and for your confidence in my abilities during our joint projects. Additionally, I am thankful for working with many talented students at TUM, with whom I got to collaborate.

From day one, I have met and worked with many great people at fortiss and the KrcmarLab at TUM, many of whom have become close friends. Undoubtedly, this project would not have been possible without my companions at fortiss: Alejandro, Andi, Arne, Julian, Julius, Markus, Matze, Norman, Rainer, and Stefan. Thank you.

Last but not least, this dissertation demanded perseverance not only on my part but from my family, friends, and the very beginning, my partner Maxi. Thank you for your unconditional support, love and inspiration now and in the future.

Munich, July 2022 Martin Engert

Abstract

Problem Statement: Digital platform ecosystems are the dominant model for large-scale value co-creation among actors. The success of platform firms depends on their ability to engage third-parties and build an ecosystem around their platform. Prominent examples can be found in the enterprise software industry, where platform firms provide customers with a core technology that is being extended by complementary products and services. As platforms and their ecosystems grow in size and complexity, so do the challenges of managing the engagement of complementors individually and collectively. While scholars in various fields have gained insights into complementors' activities, a comprehensive understanding of complementor engagement and its management is missing. In addition, platform owners have to process extensive information on activities and relationships within their ecosystems to allocate resources effectively.

Research Design: To address this gap, we first conducted a literature review on the adoption of digital platform ecosystems by complementors. We uncover a range of factors and their effective directions that contribute to complementors' platform adoption as the starting point for their engagement with the platform ecosystem. Subsequently, we follow a qualitative research strategy, applying different methods. First, we conduct an embedded case study to identify more nuanced manifestations of complementor engagement and complementors' utilization of platform boundary resources. Second, we explore mechanisms through which complementors balance the value for customers and the platform owner in a single case study. Third, a multiple case study on partner programs in the enterprise software industry revealed criteria and metrics to manage complementor engagement in platform ecosystems. Lastly, we used design science research to build and evaluate a tool prototype for platform owners to support partner managers in operational and strategic tasks by providing relevant information.

Results: This dissertation provides comprehensive insights into complementor engagement and its management. Starting with complementors' initial adoption decision, we create a detailed overview of the factors relevant to complementors in digital platform ecosystems. Furthermore, we empirically explore how complementors engage with digital platform ecosystems and describe two engagement goals, five engagement types, and their manifestations. For example, complementors develop products, ensure compliance with the platform and cooperate with their peers. This detailed account of complementor engagement is complemented by two mechanisms through which complementors allow technology firms to exploit their digital technology. Additionally, we derive a taxonomy of criteria and metrics for platform owners to assess complementors towards an information-based management approach.

Contribution: This dissertation contributes to research on digital platform ecosystems. First, we broaden the perspective on complementors and highlight the complexity underlying their continued engagement in platform ecosystems. Thus, we go beyond the standard view of extant work that once complementors adopt a platform, they engage unconditionally and within the governance framework of the platform owner. Second, we contribute a market-based perspective on managing technology platforms. The proposed framework serves platform owners to address the dialectic tension of customization and generalization for customers by

evaluating actions and ways to engage complementors. Third, this dissertation advances information-based management approaches to platform ecosystems and proposes an information capability for platform owners.

Study Limitations: The study has two main limitations besides others. First, data analysis is subject to concerns regarding internal validity. Researchers' interpretation of qualitative data is prone to subjectivity, which cannot be entirely eliminated. We mitigated this limitation by adhering to a structured coding process and involving at least two researchers during data analysis in our publications. Second, the generalizability of qualitative approaches is vulnerable due to unique conditions present in case studies. We address this limitation by building our studies on multiple units of analysis or multiple cases and adding supplementary materials for triangulation.

Future Research: This dissertation provides rich grounds for future work, which we catalog into five avenues for future work. First, acknowledging that complementor engagement with platform ecosystems changes over time, we encourage researchers to investigate continued and sustained complementor engagement. Empirical insights into how engagement unfolds and what drives and slows resource investments by complementors will shape platform owner and complementor strategies in the future. Second, this dissertation acknowledges complementors' autonomy in deciding their resource commitments. Nevertheless, more work is required to understand how complementors can capitalize on their autonomy through collaborations and how platform owners can balance the associated upsides and downsides. Third, IS research investigated information technologies and their impact on business customers and consumers. We call for more research on platform owners as technology providers and how they can position their technology within the market in light of strategic contradictions such as customization and generalization. Fourth, information-based management of digital platform ecosystems is a (big) data-driven exercise. Future work should investigate the programmatic use of analytics and the capabilities for its successful implementation. Last, we provide a tool prototype for partner managers. Extending the tool to other stakeholders and their information needs will allow further insights into the interrelations of platform ecosystems and the inner workings while providing practitioners with helpful artifacts.

Table of Contents

List of Figures

List of Tables

List of Abbreviations

AMCIS	Americas Conference on Information Systems
API	Application Programming Interface
B2B	Business-to-Business
B2C	Business-to-Customer
CMS	Content Management Systems
CON	Conference
CRM	Customer Relationship Management
DSR	Design Science Research
ECIS	European Conference on Information Systems
ENTER	ENTER eTourism Conference
ICIS	International Conference on Information Systems
ISF	Information Systems Frontiers
JNL	Journal
KPI	Key Performance Indicator
LR	Literature Review
MISQ	Management Information Systems Quarterly
NR	Not Ranked
P	Publication
PACIS	Pacific Asia Conference on Information Systems
PBR	Platform Boundary Resource
RQ	Research Question
SDK	Software Development Kit
VHB	Verband der Hochschullehrer für Betriebswirtschaft
WI	Internationale Tagung Wirtschaftsinformatik

Part A

1 Introduction

> *"Today, platform companies are in nearly every market, and they all share common features. They use digital technology to create self-sustaining positive-feedback loops that potentially increase the value of their platforms with each new participant. They build ecosystems of third-party firms and individual contractors that allow them to bypass the traditional supply chains and labor pools required by traditional companies."* (Cusumano et al., 2020)

This quote by Cusumano et al. (2020) compiles the essence of platform companies' success while implicating a cautionary note for all platform firms: The creation of positive-feedback loops hinges on the engagement of an ecosystem of autonomous third-parties. In this dissertation, we build an empirical understanding of the engagement of third-party complementors. In particular, we uncover what motivates third-parties to join platform ecosystems, describe and systemize how they engage with ecosystems and develop ways for platform owners to establish information-based approaches to managing their complementor ecosystems.

1.1 Motivation and Problem Statement

> *"Our success depends on the willingness of a growing community of third-party developers and technology providers to build applications and provide integrations, data and content that are complementary to our services. Without the continued development of these applications and provision of such integrations, data and content, both current and potential customers may not find our services sufficiently attractive, which could impact future sales."* (Salesforce, 2021, p. 28)

The emergence of digital platform ecosystems has reshaped how we live and conduct business. People worldwide seek information and news via platforms (e.g., Google), stay in touch with friends and family (e.g., WeChat), or order food online (e.g., delivery hero). Moreover, we rely on platforms in our daily work (e.g., SAP), management of customer relationships (e.g., Salesforce), and the use of cloud-computing power (e.g., Microsoft Azure).

Despite their differences in customers and industries, these platforms share one defining characteristic; they rely on complementary activities from an ecosystem of autonomous actors, commonly referred to as *complementors* (Gawer, 2014). Salesforce, for instance, leverages a complementor ecosystem, which sells and implements its customer relationship management software, develops new applications, trains users, and exchanges technical and market knowledge. The examples illustrate that each complementor engages in various interactions, takes different roles, and co-creates value in various forms, which could not be accomplished by Salesforce alone. Hence, it is not surprising that Salesforce plans to increase the number of consulting professionals of complementors to 250,000 by 2022[1].

---

[1] https://www.salesforce.com/company/news-press/press-releases/2019/05/192315-mm/

Digital platforms are a technical infrastructure, an "extensible codebase of a software-based system that provides core functionality" (Tiwana et al., 2010, p. 675). For example, Salesforce is a platform owner that offers Customer-Relationship-Management (CRM) software as the platform's core functionality. An ecosystem of autonomous complementors interacts with the platform in various ways: On the one hand, Independent Software Vendors (ISVs) create applications with functionalities such as project management, surveys, and resource management. On the other hand, consultants and implementation specialists promote, sell and implement the platform to customers, extending the platform offerings. Customers consume the platform's functionality and complementary products and services as part of one overall platform ecosystem value proposition (Adner, 2017).

While the utilization of an ecosystem of complementors shifts the effort of value creation outside of the firm (Parker et al., 2017), it also comes at the cost to build, orchestrate and sustain the ecosystem (Dattée et al., 2017; Williamson & Meyer, 2012). Not only Salesforce but all firms that employ a platform ecosystem face the challenge of determining the state and prospects of individual partnerships and simultaneously monitoring the growth and evolution of the ecosystem as a whole (Cennamo & Santalo, 2019; Panico & Cennamo, 2022; Tiwana, 2014). As a result of the complex interactions and interrelations in digital platform ecosystems, managing and processing extensive information on relationships becomes a critical capability (Hinz et al., 2020; Leong et al., 2019). Therefore, a more nuanced comprehension of complementor engagement will help platform owners create these advanced information capabilities for focused ecosystem management (McIntyre et al., 2020). We approach these issues based on three research questions (RQs), the answers of which will create the much-needed understanding regarding the stimulation and manifestation of complementor engagement and its respective information-based management.

First, complementor engagement is initiated by complementors' decision to join a specific digital platform ecosystem. As stressed by extant literature, a "[..] better understanding of *tactics and governance mechanisms* [sic!] that hub firms use to recruit, motivate and retain participants will be helpful." (Jacobides et al., 2018, p. 2268). Additionally, P. Song et al. (2018) found that the supply-side of digital platforms is slower in adopting ecosystems than the demand-side when demand is high and vice versa. These insights urge platform owners to reduce barriers to entry for complementors and actively engage them.

Second, interactions within a platform ecosystem are more complex than application development, comprising additional activities such as knowledge sharing (e.g., Jha et al. (2019)), signaling (e.g., Hevner and Malgonde (2019)), and vertical specialization (J. Li et al. (2019)). Hence, a necessary precondition to information-based ecosystem management is a comprehensive understanding of the underlying interactions and contributions of complementors within the ecosystem. At the same time, there are widely unanswered calls for further investigation of different kinds of collaboration and coordination behaviors in ecosystems (Benlian et al., 2018; Eaton et al., 2015; Jacobides et al., 2018).

Third, as resources of platform owners are generally scarce, distributing them among complementors effectively while managing complex complementor ecosystems remains a considerable challenge for platform owners (Adner, 2017; Jacobides et al., 2018; McIntyre et al., 2020; McIntyre & Srinivasan, 2017). For instance, pursuing short-term local optima such as increasing individual revenue may contrast with long-term ecosystem growth (Huber et al., 2017). To mitigate this problem, firms rely on performance indicators and sensing capabilities (Teece, 2017) to effectively monitor and steer the ecosystem (Graça & Camarinha-Matos, 2017; Kohli & Grover, 2008). Indicators such as the number of application downloads or revenue shared per complementor are generally available to platform owners. However, structured, tool-based approaches for creating more advanced insights and supporting platform managers are missing as the basis for informed decision-making (Helfat & Raubitschek, 2018; Hinz et al., 2020).

1.2 Research Questions

This dissertation aims to generate insights into the engagement of complementors, starting with their adoption decision. Increasing our understanding of complementor engagement lays the foundation for utilizing meaningful metrics and key performance indicators (KPIs) for managing complementors individually and collectively. We take an empirical stance and integrate the literature on digital platform ecosystems with qualitative data of different platform ecosystem cases to answer the following research questions:

RQ1: *What factors influence complementors' decision to adopt a digital platform ecosystem?*

The first research question builds the basis for this dissertation project and investigates the initial adoption decision of complementors as the starting point for their engagement with the platform ecosystem (Tan et al., 2015; Wan et al., 2017). Therefore, we focus on extant research on digital platform ecosystems to better understand the factors influencing complementors' platform adoption. We build the design of our literature review on the guidelines of Webster and Watson (2002) and Vom Brocke et al. (2009). Hence, our research validity is strengthened. The review resulted in 43 factors influencing the adoption decision of customers and complementors as the initialization of their engagement. We further investigated the factors' respective effective directions.

RQ2: *How do complementors engage in digital platform ecosystems?*

The engagement of complementors, i.e., their decisions and subsequent actions to invest and contribute resources continuously within a digital platform ecosystem, is a fundamental success factor for digital platform ecosystems (Ceccagnoli et al., 2012; Jacobides et al., 2018). By answering this research question, we deepen our understanding of complementor interactions beyond the provision of complements and explore more nuanced facets of interactions among ecosystem actors. We do so using a multiple case study (Eisenhardt, 1989; Yin, 2018) on Content Management Systems (CMSs) in the e-commerce context. Mainly, we focus on the role of (Platform Boundary Resources) PBRs in motivating, enabling, and supporting complementor engagement. The results show that complementor engagement has different manifestations, and all engagement types are associated with PBRs. Our study also reveals different categories and effects of PBRs for complementor engagement. In addition, we employ a single case study and examine how Celonis engages its partner ecosystem to manage the interpretive flexibility (W. Chen et al., 2009; Doherty et al., 2006) of its process mining technology. The study reveals two essential mechanisms through which complementors balance the value for customers and the platform owner.

RQ3: *How can platform owners use information to manage complementor engagement in digital platform ecosystems?*

Organizations utilize information to make appropriate decisions in light of uncertainty (Galbraith, 1974; Premukmar et al., 2005). Similarly, platform owners can create and use information from metrics and KPIs for their decision-making (Fotrousi et al., 2014; Plakidas et al., 2017). We follow a two-step approach to answer this research question. We first conduct a multiple case study (Yin, 2018) in the enterprise software industry and derive a taxonomy of criteria and metrics from assessing complementors. Further, we provide insights into the characteristics of partner programs as one key element for the information-based management of complementor ecosystems. Second, we deploy design science research (DSR) (Hevner et al., 2004; Peffers et al., 2007) to develop and evaluate an IT artifact, which supports partner managers in their decision making. The artifact provides information on complementors individually and collectively for the tasks of partner managers.

In essence, we first create a comprehensive understanding of the factors influencing complementors' adoption decisions. Next, we explore how complementors engage with platform ecosystems and how platform owners can utilize information to manage complementors.

1.3 Structure

The dissertation comprises three parts (see Figure 1). Part A introduces the research field of digital platform ecosystems and emphasizes the role of complementors. Furthermore, it motivates the current thesis and outlines the problem statement using three research questions and the structure of the thesis (Chapter 1). The following section provides the conceptual background for this thesis, comprising digital platforms, digital platform ecosystems, complementors as important actors in these ecosystems, complementors' interactions, and mechanisms for platform owners to manage complementors and their engagement (Chapter 2). The last section of Part A outlines the research design of the current thesis, consisting of the research paradigm, the qualitative research strategy, and the research methods utilized (Chapter 3).

Part B presents the five published and peer-reviewed publications (P) that follow the structure of the three research questions. To answer the first research question, we conduct a literature review on the factors influencing users' and complementors' adoption decisions (Chapter 1). The second research question is addressed by a multiple case study in the context of e-commerce platform ecosystems and a single case study on Celonis (Chapter 2-3). The remaining publications answer research question three using a multiple case study and a design science study (Chapter 4-5).

In part C, we first summarize our results from all five publications (Chapter 1). Then, we discuss the insights and findings from the articles concerning complementor's varying engagement over time, approaches to manage technology platforms and platform owners' information capability (Chapter 2). Moreover, we highlight the implications for practice (Chapter 3), consider the limitations of this thesis (Chapter 4), present opportunities for future work (Chapter 5), and conclude the dissertation in a final résumé (Chapter 6).

Part A	**Introduction, conceptual background, research approach**	
Part B	**Published articles**	
	RQ1: What factors influence complementors' decision to adopt a digital platform ecosystem?	
	P1	*Adoption of Software Platforms: Reviewing Influencing Factors and Outlining Future Research* **Method:** Structured literature review
	RQ2: How do complementors engage in digital platform ecosystems?	
	P2	*The Engagement of Complementors and the Role of Platform Boundary Resources in e-Commerce Platform Ecosystems* **Method:** Case study research
	P3	*Managing the Interpretive Flexibility of Technology: A Case Study of Celonis and its Partner Ecosystem* **Method:** Case study research
	RQ3: How can platform owners use information to manage complementor engagement in digital platform ecosystems?	
	P4	*Partner Programs and Complementor Assessment in Ecosystem Governance: A Multiple-Case Study* **Method:** Case study research
	P5	*Supporting Partner Management in Enterprise Digital Platform Ecosystems – A Design Science Research Study* **Method:** Design science research
Part C	**Summary of results, discussion, limitations, implications, future research**	

Figure 1. Structure of the Dissertation

The following paragraphs summarize the five publications embedded in part B of the current thesis (see Table 1). We outline the research problem, research approach, and main contributions for each publication.

Table 1. Publications Embedded in this Thesis

RQ	No.	Authors	Title	Outlet	Type
RQ1	P1	Engert, Pfaff, Krcmar	Adoption of Software Platforms: Reviewing Influencing Factors and Outlining Future Research	PACIS* 2019	CON (VHB: C)
RQ2	P2	Engert, Evers, Hein, Krcmar	The Engagement of Complementors and the Role of Platform Boundary Resources in e-Commerce Platform Ecosystems	ISF* 2022	JNL (VHB: B)
	P3	Engert, Chu, Hein, Krcmar	Managing the Interpretive Flexibility of Technology: A Case Study of Celonis and its Partner Ecosystem	ICIS* 2021	CON (VHB: A)
RQ3	P4	Engert, Hein, Krcmar	Partner Programs and Complementor Assessment in Ecosystem Governance: A Multiple-Case Study	AMCIS* 2020	CON (VHB: D)
	P5	Engert, Fuchs, Hein, Krcmar	Supporting Partner Management in Enterprise Digital Platform Ecosystems – A Design Science Research Study	PACIS* 2021	CON (VHB: C)

Outlet:
AMCIS: Americas Conference on Information Systems
ICIS: International Conference in Information Systems
ISF: Information Systems Frontiers
PACIS: Pacific Asia Conference on Information Systems

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

*all publications are published and peer-reviewed.

P1: Adoption of Software Platforms: Reviewing Influencing Factors and Outlining Future Research. The first publication (Engert et al., 2019) addresses the fundamental issue for the platform owner to generate growth through driving platform adoption by users and complementors. The implementation of engagement strategies hinges on a thorough understanding of the factors and mechanisms that impact the adoption of users and complementors. To that end, the article provides a structured outline of essential concepts in platform ecosystem growth, such as the chicken-and-egg problem, critical mass, and network effects. The first article is based on a structured literature review and identifies the factors influencing the decision to adopt by users and complementors. For each factor, the article indicates whether it directly and/or indirectly affects this adoption decision. Based on this distinction, the factors are organized as universal, semi-universal, and specific factors according to their influence on the respective sides. The article concludes with three avenues for future research: connecting platform launch and governance concepts, the evolution of platform governance, and an empirical investigation of platform launch strategies.

P2: The Engagement of Complementors and the Role of Platform Boundary Resources in e-Commerce Platform Ecosystems. The second contribution (Engert et al., 2022) spotlights the engagement of complementors in digital platform ecosystems. It gives particular attention to the role of boundary resources in motivating and allowing complementors to engage. In the theoretical background, the article elaborates on the main concepts, including digital platform ecosystems, PBRs, and the engagement of complementors as autonomous actors. In this article, we use three cases of content management platforms in e-commerce to identify and describe two complementor goals: ensuring platform alignment and driving innovation and success. Complementors build on five types of complementor engagement to reach these goals: developing products, ensuring compliance, enhancing products, commercializing products, and cooperating. Each of the types has two concrete manifestations. Furthermore, we identify the

PBRs relevant for each type and distinguish uniform and individual PBRs. Generally, these PBRs affect innovation, governance, and communication. The discussion first introduces the novel concepts of complementor resourcing and complementor securing vis-à-vis the PBRs provided. Second, we discuss the scalability of PBRs in light of the standardization-individualization tension and the dominant design of PBRs across industries. Practitioners gain novel insights into the strategic design of PBRs and ways for managers on the complementor side to create competitive advantages by using them.

P3: Managing the Interpretive Flexibility of Technology: A Case Study of Celonis and its Partner Ecosystem. The third contribution (Engert, Chu, et al., 2021) proposes a framework for platform owners to manage the interpretive flexibility of their technology and the role of partners in doing so. Digital technologies are perceived and used differently by different users, leading to diverse outcomes when applying the same technology to similar settings – a property described as a technology's interpretive flexibility. Technology firms such as Celonis need to balance and manage this interpretive flexibility to deliver meaningful solutions to individual customers while keeping as many market opportunities open. Our study suggests that technology firms can engage partner ecosystems to increase or decrease the interpretive flexibility of their technology for customers. We describe two mechanisms, abstraction and deployment, that allow platform owners to do so. Importantly, we find that platform owners have to provide partners with the means necessary to use the technology themselves. The article contributes to research on managing IT technologies such as process mining. It gives practitioners a novel perspective on the goals and mechanisms underlying partner management in digital platform ecosystems.

P4: Partner Programs and Complementor Assessment in Ecosystem Governance: A Multiple-Case Study. The fourth contribution (Engert et al., 2020) sheds light on the ways to assess complementors as practiced in the enterprise software industry. Partner programs constitute a significant governance mechanism for platform owners that define requirements and goals for partners in various partner tiers using different criteria and metrics. Based on these metrics, partners are being assessed and categorized individually, and these partne program requirements can inform the information-based management approaches of platform owners. The third article identifies criteria and metrics from different partner programs as part of a multiple case study in the enterprise software idustry. It builds a taxonomy of criteria and metrics to assess complementors in two different roles. Additionally, the article highlights different characteristics of partner programs, which differ in their assessment modes and intervals. Practitioners benefit from a comprehensive collection of criteria and metrics to assess complementors and gain general insights into different approaches to setting up partner programs. The article informs research on platform ecosystems and suggests complementor assessment as one important source to manage large numbers of partners.

P5: Supporting Partner Management in Enterprise Digital Platform Ecosystems – A Design Science Research Study. The fifth publication (Engert, Fuchs, et al., 2021) demonstrates the value of a tool to support decision-making in partner management in platform ecosystems. Partner management is critical for platform owners, balancing several governance tensions, and the availability of information to partner managers in their daily tasks helps address them. To that end, the fifth article provides a brief overview of general governance tensions. It then utilizes a design science research approach to develop a tool prototype that computes, provides, and visualizes information for partner managers. Based on interviews with nine partner managers from three enterprise software platforms, the tasks of partner managers, tool requirements, and related design principles for the artifact are derived. After the artifact's design as a web application, the article demonstrates the prototype using a simulation and subsequently evaluates the artifact's utility and effectiveness. The tool enables and promotes information-based management approaches and advances platform owners' capacity to manage complementors and their engagement in digital platform ecosystems.

Besides the five main publications, we worked on various additional publications embedded in the current dissertation (see Table 2). Co-authors often lead these additional publications, which indirectly relate to the research questions, thus presenting valuable complements to the embedded publications.

Concerning RQ1, the article by Baecker et al. (2020) provides an overview of general data monetization strategies. One strategy detailed in this article describes the strategic opening of data, which is particularly suitable for platform companies to stimulate ecosystem growth.

Related to RQ2, we analyzed the evolution of a platform business model using the example of ServiceNow and the mechanisms deployed to engage an ecosystem of complementors (Schaffer et al., 2021). Moreover, Schaffer, Engert, Sommer, Shokoui, and Krcmar (2021) developed an ecosystem model for the European tourism industry, exemplifying the complexity of ecosystems and related interactions on the domain level.

Regarding RQ3, we developed a tool to model and simulate dynamic business models, enabling platform owners to create data-driven simulations and derive actions. We demonstrate and evaluate the tool using the example of a data-driven platform business model in the tourism industry (Schaffer et al., 2020).

Despite the value and insights of the additional publications, we selected publications P1 to P5 as the critical building blocks to be embedded in this dissertation.

Table 2. Overview of Additional Publications

RQ	Authors	Title	Outlet	Type
RQ1	Baecker, Engert, Pfaff, Krcmar	Business Strategies for Data Monetization: Deriving Insights from Practice	WI* 2020	CON (VHB: C)
RQ2	Schaffer, Ritzenhoff, Engert, Krcmar	From Specialization to Platformization: Business Model Evolution in the Case of ServiceNow	ECIS* 2021	CON (VHB: B)
	Schaffer, Engert, Sommer, Shokoui, Krcmar	The Digitized Ecosystem of Tourism in Europe: Current Trends and Implications	ENTER* 2021	CON (VHB: NR)
RQ3	Schaffer, Engert, Leontjevs, Krcmar	A Tool to Model and Simulate Dynamic Business Models	BLED* 2020	CON (VHB: NR)

Outlet:
BLED: Bled eConference
ECIS: European Conference on Information Systems
ENTER: ENTER eTourism Conference
WI: Internationale Tagung Wirtschaftsinformatik

Type:
CON: Conference
NR: Non-ranked
VHB: German Academic Association for Business Research

*all publications are published and peer-reviewed.

2 Conceptual Background

The conceptual background presents the key concepts on which we build the current thesis. First, we introduce digital platforms and digital platform ecosystems. Next, we focus on complementors as a critical group of actors within digital platform ecosystems and their interactions with other actors. Third, we provide an overview of the ways complementors can be managed by platform owners and indicate the potential role of information in doing so.

1.4 Digital Platforms

Digital platforms as a construct have been defined and investigated through different perspectives and by different disciplines. Generally, we distinguish two broad categories of digital platforms: innovation platforms and transaction platforms (Bonina et al., 2021; Cusumano et al., 2020).

Transaction platforms facilitate transactions among groups of actors on two or more sides of a platform (Helfat & Raubitschek, 2018). These groups often comprise users on the demand side of the platform and providers of complementary products and services on the supply side of the platform (McIntyre et al., 2020). In this context, digital platforms are often referred to as multi-sided platforms (Bonina et al., 2021; Hagiu & Wright, 2015; Hein, Schreieck, Wiesche, et al., 2019).

Researchers investigating transaction platforms usually take an economics perspective to focus on the interactions between and among demand-side and supply-side actors, which lead to network effects (Hinz et al., 2020). Direct network effects describe interdependencies between these groups, such as the positive externalities of more sellers on online marketplaces like eBay and Alibaba.com for users (Uotila et al., 2017). Additionally, indirect network effects describe interdependencies among user groups, such as the negative competitive effects of a large number of applications in the mobile phone application marketplace (Boudreau, 2012). Both direct and indirect network effects are important drivers for the attractiveness and viability of digital platform ecosystems for users and complementors (Stummer et al., 2018). Thus, creating and managing network effects is the key to establishing successful platforms (Cennamo & Santalo, 2013; McIntyre & Srinivasan, 2017).

Innovation platforms facilitate interactions among actors, enabling knowledge exchange and recombination, leading to innovative outcomes, such as co-created products and services (Cusumano et al., 2020; Faraj et al., 2016). The ability of a platform to drive and produce these innovation processes is referred to as its generativity (Cennamo & Santalo, 2019; Zittrain, 2006).

Research investigating innovation platforms utilizes perspectives from innovation management and software engineering design (Gawer, 2014). Typical examples of innovation platforms are software-based platforms with third-party application marketplaces. These platforms represent an extensible codebase providing core functionality extended by modular subsystems (Tilson et al., 2010; Tiwana et al., 2010). Enabling third-parties to contribute while controlling their contributions are key topics for research on innovation platforms (Ghazawneh & Henfridsson, 2013; Schreieck et al., 2016).

In practice, many digital platforms combine elements and characteristics of both transaction and innovation platforms. The SAP cloud platform, for instance, is an innovation platform, allowing complementors to create innovative products and services based on SAP's platform technology. At the same time, the platform's application marketplace allows complementors to show and sell their applications to users, acting as a transaction platform (Schreieck et al., 2019; Schreieck et al., 2021).

Therefore, in the context of this thesis, digital platforms represent a software-based system that can be extended by third-party complementors' modules and which facilitates complementors' interactions with platform users (De Reuver, Sørensen, & Basole, 2018; Jacobides et al., 2018; Tiwana et al., 2010). The considerations concerning the interactions among multiple actors through and around digital platforms lead to the emergence and scholarly attention to the socio-technical concept of digital platform ecosystems (Hein, Schreieck, Riasanow, et al., 2019).

1.5 Digital Platform Ecosystems

Digital platform ecosystems consist of a multitude of autonomous actors, usually divided into complementors that represent the supply side, users that represent the demand side, and a platform owner that orchestrates supply and demand (De Reuver, Sørensen, & Basole, 2018; Gawer, 2014; Hein, Schreieck, Riasanow, et al., 2019). Following Hein, Schreieck, Riasanow, et al. (2019, p. 90), a „digital platform ecosystem comprises a platform owner that implements governance mechanisms to facilitate value-creating mechanisms on a digital platform between the platform owner and an ecosystem of autonomous complementors and consumers."

Modules developed by third-party complementors, such as apps from Salesforce's AppExchange, extend the core functionality of the platform, which is Salesforce's CRM software. Users can integrate apps, for example, a feedback survey functionality provided by SurveyMonkey, into their instantiation of the Salesforce platform, leading to direct interactions between users and complementors. The availability of these additional applications and services via the platform attracts users (Adner, 2017; Hein, Schreieck, Riasanow, et al., 2019; Teece, 2018). Complementors, in turn, are attracted to the ecosystem due to the easy accessibility of a large group of users, creating network effects across the ecosystem (Farrell & Saloner, 1986; Hinz et al., 2020).

The platform owner designs and continuously adapts the underlying platform to facilitate these value-creating interactions through the provision of PBRs and the implementation of governance mechanisms (Ghazawneh & Henfridsson, 2013; McIntyre et al., 2021; Schreieck et al., 2017, 2018). Salesforce provides a Software Development Kit (SDK) as a PBR to incentivize and enable developers to create applications. Furthermore, Salesforce and others offer their SDK documentation openly to every interested party, revealing significant technological knowledge (Foerderer et al., 2019).

1.6 Complementors in Digital Platform Ecosystems

Complementors extend the platform functionality while having considerable autonomy (Bergvall-Kåreborn & Howcroft, 2014; Valença & Alves, 2017; Xue et al., 2019). Steering a large number of autonomous complementors requires the platform owner to overcome tensions such as striking a balance between the mode of governance regarding standardized and individualized approaches, with the last being highly resource-intensive (Boudreau, 2010; Foerderer et al., 2018). Platform owners leverage different resources and mechanisms such as partner programs or pre-defined roles to address those tensions (Halckenhaeusser et al., 2020a; Wareham et al., 2014). For instance, complementors of the Salesforce ecosystem may choose two tracks. AppExchange partners develop and innovate applications that add to the functionality of the platform. Consulting partners sell the Salesforce platform comprising the third-party applications to users and customize and integrate the solution. While complementors are distinguished according to their primary roles within the ecosystem, they often specialize vertically regarding industries or technologies (Tavalaei & Cennamo, 2021). Generally, complementors evaluate the adoption of new platforms and strategize to grow their business and drive value generation (Cenamor, 2021; Koch & Guceri-Ucar, 2017).

In conclusion, the contribution of resources of complementors to interactions with other ecosystem actors co-creates value (Hein, Weking, et al., 2019; Schreieck et al., 2021). The engagement of complementors, therefore, determines the level of value creation of an ecosystem (Saadatmand et al., 2019).

1.7 Managing Complementors

Complementors create value in various ways, consequently differing vastly within and across ecosystems concerning their types of strategies, resources, capabilities, and dedication (Helfat & Raubitschek, 2018; Hurni et al., 2021; Nambisan et al., 2018; Nambisan et al., 2019). The literature on digital platform ecosystems reports on many different interactions of complementors. A focal actor's interactions can be distinguished as transactional (i.e., related to the core transactions among actors) and non-transactional (i.e., related to further transactions among actors) (Verhoef et al., 2010). In the context of complementors in digital platforms, the core transactions are the provision and maintenance of functional modules (e.g., Goldbach et al. (2018) and Ozalp et al. (2018)) and provision of services such as consulting and implementation (e.g., Sarker et al. (2012) and Wareham et al. (2014)). These interactions and their consequences for the ecosystem have received significant attention in prior work on digital platforms. Examples of non-transactional activities are exchanging legal knowledge with peer complementors (Shilton & Greene, 2019) or sharing intellectual property with the platform owner (e.g., Perrons (2009), Ceccagnoli et al. (2012) and Karhu et al. (2018)). The differentiation allows researchers and platform owners to distinguish among complementors and prioritize their interactions while allowing particular focus on the non-transactional activities, which have not been considered in the majority of studies.

What is common to all interactions of complementors is the underlying purpose of (co-)creating value for certain actors, establishing a link between interaction and an associated value outcome. The following paragraphs provide an overview of the different interactions of complementors from literature, grouped into four types according to the actor's respective counterparts.

Complementor Engagement in Digital Platform Ecosystems

The analysis of prior work on complementor interactions revealed different interactions with different groups of actors in digital platform ecosystems. Interactions can be directed towards users, the platform owner, peer complementors, or self-oriented. Furthermore, we distinguish the transactional and non-transactional nature of the respective interactions. We follow integrate different conceptualizations in prior work and introduce the term Complementor Engagement to capture the heterogeneity of interactions (Jacobides et al., 2018; Saadatmand et al., 2019; Verhoef et al., 2010). Complementor Engagement *comprises a complementor's transactional and non-transactional interactions with the digital platform ecosystem and its actors that form an ongoing and iterative process*.

The following sections elaborate on complementor interactions with different ecosystem actors, which are fundamental to complementor engagement.

User-focused interactions are related to the products and (additional) services complementors provide to the users within an ecosystem, including transactional and non-transactional activities. For instance, a complementor creating a complement for a platform engages in development-related interactions (e.g., Boudreau and Jeppesen (2015) and Boudreau (2010)). Furthermore, implementing the complement or the platform at the user's site constitutes a service-related interaction (Wareham et al., 2014), both considered transactional. At the same time, activities such as training the user firm's employees (e.g., Sarker et al. (2012) and Wareham et al. (2014)) represent additional services, which are non-transactional interactions. Most importantly, however, all three types of user-focused interactions co-create value between the complementor and the user.

Furthermore, there are **platform-owner-focused interactions** of complementors, which comprise the core transactions among platforms and complementors and non-transactional interactions. Hence, when sharing revenue with the owner or paying fees, complementors engage in transactional interactions (e.g., Nambisan et al. (2018) and Wareham et al. (2014)). In contrast, complementors requesting new platform features or giving feedback on platform changes (e.g., Hevner and Malgonde (2019)) pose non-transactional interactions. Notably, both create value for the platform owner.

Additionally, extant literature reports on **interactions focused on other complementors**. They engage in shared research and development activities or collaborate in other ways to create a joint value proposition for users (Plakidas et al., 2017; van Angeren et al., 2016). These interactions are considered transactional. In contrast, non-transactional interactions among complementors mainly happen within community forums of complementors or during events, which the platform owner often moderates or holds (Foerderer, 2020). Examples are the sharing of technical or market-related knowledge or best practices. Huang et al. (2018) show how SAP incentivizes complementors to engage within the community using a contributor recognition program, awarding points for questions and answers. Through these interactions among complementors, value is generated for all actors involved.

Moreover, complementors interact with the ecosystem in a way that is **self-oriented**. These interactions have the purpose of creating value for the respective complementor. For instance, selling apps or platform licenses to users are transactional self-oriented interactions generating revenues (e.g., Sarker et al. (2012)). Furthermore, value capturing activities such as collecting user data (e.g., Kummer and Schulte (2019)) or protecting intellectual property with formal and informal mechanisms (e.g., Miric et al. (2019)) are characterized as non-transactional and self-oriented. Also, interactions that aim at aligning the complementor with the rest of the ecosystem through, for example, joining partner programs (van Angeren et al., 2016) create value for the complementor in a non-transactional way.

Second, the analysis of extant work reveals the underlying mechanisms of how platform owners can manage and steer complementor engagement.

Mechanisms for the Platform Owner to Steer Complementor Engagement

Information and the Assessment of Complementors

The creation of visibility into the interactions across their ecosystem is fundamental for platform owners to determine the state and evolution of individual partnerships and the ecosystem as a whole (Cennamo & Santalo, 2019; Panico & Cennamo, 2022; Tiwana, 2014). This ability allows monitoring problems and changes within the ecosystem, initiating the necessary design and governance decisions, and tracking the effectiveness of measures. However, these activities are subject to the platform owner's availability and exploitation of information.

Although every organization should develop information capabilities, platform owners' information capabilities differ from traditional firms. Value creation in platforms happens to a high degree outside the firm, where value is co-created among many different actors (Parker et al., 2017; Sarker et al., 2012). Accordingly, success metrics and KPIs of platforms differ from those of traditional organizational forms due to their focus on multiple actors instead of a single organization (Graça & Camarinha-Matos, 2017; Plakidas et al., 2017).

Salesforce's deployment decision of limited one-to-one resources to certain complementors is contingent on timely and comprehensive information and a strategic map of metrics to follow. However, since a complementor's value contribution to the ecosystem may depend on its transactional and non-transactional interactions, Salesforce is challenged to understand these individual interactions and their respective value to the ecosystem. Nonetheless, knowledge of the information capabilities of platform owners is scarce, and ways for assessing complementors and platform ecosystems as a whole lack theoretical grounding (Fotrousi et al., 2014; Plakidas et al., 2017).

Managing Complementor Interactions

Complementors (co-)create value through various types of interactions, and platform owners implement suitable governance mechanisms and platform PBRs to manage the ecosystem of complementors. Platform owners leverage information to initialize and continuously adapt governance mechanisms and PBRs, steering the ecosystem's evolution (Eaton et al., 2015; Ghazawneh & Henfridsson, 2013).

Platform boundary resources are a significant facilitator for interactions and have received considerable attention in prior work (Eaton et al., 2015; Foerderer et al., 2019; Ghazawneh & Henfridsson, 2013; Karhu et al., 2018). PBRs build on the principle of standardization to transfer information across heterogeneous entities (Hein, Weking, et al., 2019). Salesforce, for instance, provides SDKs as one type of PBR to its complementors. Furthermore, Application Programming Interfaces (APIs), code repositories, documentation, and developing guidelines are frequently deployed PBRs (Bianco et al., 2014).

Generally, platform PBRs are used for two reasons. First, *resourcing* aims at increasing the scope and diversity of third-party applications through the enablement of complementors (Ghazawneh & Henfridsson, 2013). Second, PBRs are used for *securing,* which aims at controlling and aligning complementors through pre-defining modes and rules of interaction (Ghazawneh & Henfridsson, 2013). Eaton et al. (2015) find that PBRs emerge through an iterative process termed *distributed tuning* based on the interactions of multiple actors over time. These findings stress the importance of a deeper understanding of complementor interactions with the platform through the collective design of PBRs.

When it comes to **platform governance,** prior work emphasized the need for defining the key roles within the ecosystem and the provision of a supportive environment through the platform owner (Lusch & Nambisan, 2015). Research on digital platform ecosystems subsumes these competencies using the concept of platform governance (Schreieck et al., 2016; Tiwana et al., 2010; Tiwana et al., 2013). Platform governance aims to balance the control exercised by the central entity and ecosystem actors' incentives and innovative capacity (Constantinides et al., 2018; De Reuver, Sørensen, & Basole, 2018; Tiwana, 2015). One common governance mechanism is input control (P. Song et al., 2018; Tiwana, 2015), such as reviewing third-party applications in Salesforce's AppExchange, which every new or updated version has to undergo. In addition to restricting undesired engagement, platform owners promote desireable complementor engagement such as awards for successful complementors (Foerderer et al., 2021). Importantly, platform governance refers to technological or business-related rules and norms and entails social aspects such as trust and reciprocity within the partnership (Huber et al., 2017; Perrons, 2009).

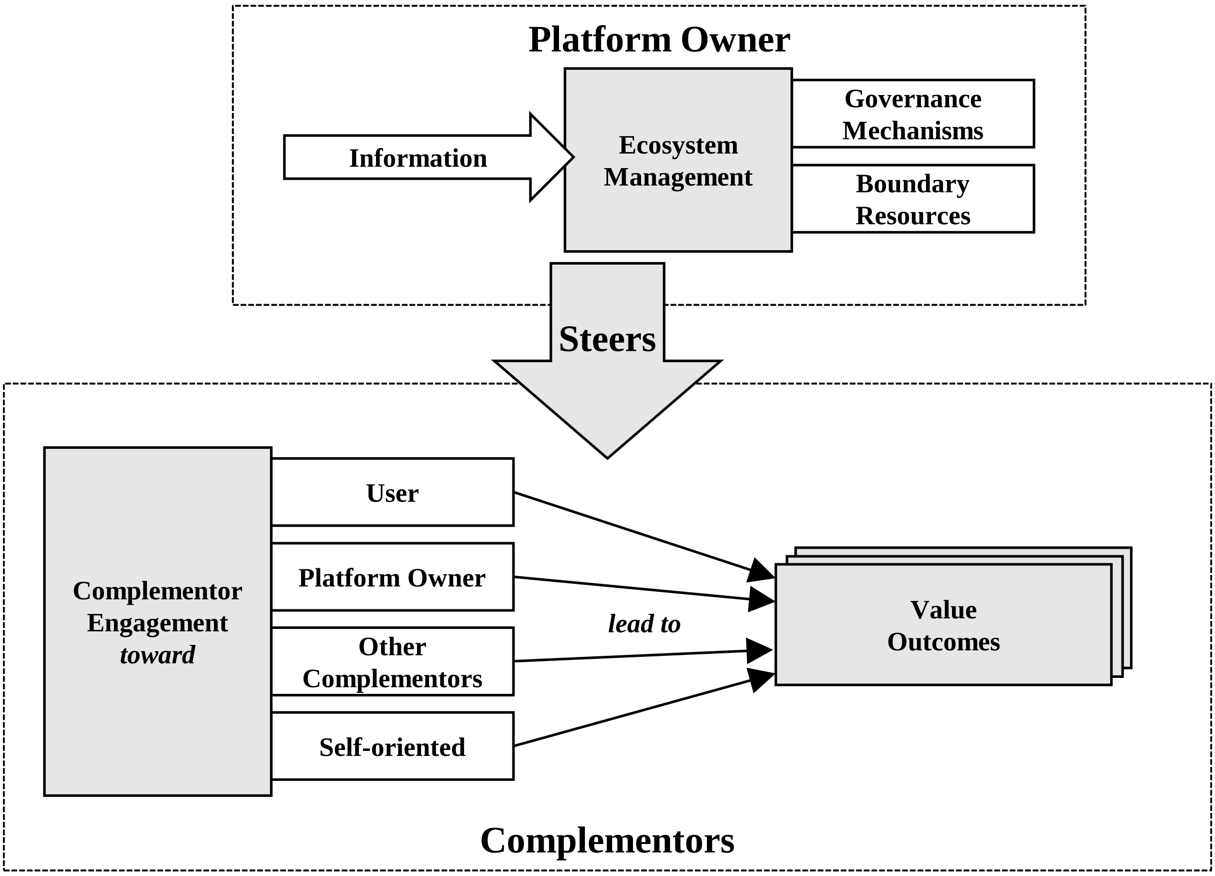

Figure 2. Illustration of Mechanisms for Platform Owners to Steer Complementor Interactions

The illustrated perspective on complementor engagement based on prior work illustrates the complexity of how complementors interact with other ecosystem actors. It acknowledges the differences in value outcomes and highlights the consequences for their management. However, it also exhibits the limitations of our current understanding. As Eckhardt et al. (2018) and Panico and Cennamo (2022) point out, there is little knowledge of the antecedents for complementors' willingness to engage. Further, collaboration, coordination, and value creation with other ecosystem actors, i.e., the modes of engagement of complementors, are largely unexplored (Benlian et al., 2018; Hein, Schreieck, Riasanow, et al., 2019; Jacobides et al., 2018). Moreover, the outcomes of these behaviors from a platform owners' perspective regarding, for instance, quantity and variety of complimentary offerings need further investigation (Cennamo & Santalo, 2019; Panico & Cennamo, 2022; Rietveld & Eggers, 2018). In constantly changing environments, the management of complementors' engagement poses a challenge, demanding further research attention (Adner, 2017; Constantinides et al., 2018; McIntyre et al., 2020; McIntyre & Srinivasan, 2017). In this context, the ongoing generation of insights through detailed information such as performance metrics to derive subsequent actions is another aspect yielding considerable research opportunities (Constantinides et al., 2018; Helfat & Raubitschek, 2018; Panico & Cennamo, 2022). Consequently, this work aims to refine the integrated view, as shown in Figure 2, addressing different calls of prior work on its further investigation. Table 3 summarizes the key concepts of the current thesis.

Table 3. Key Concepts in the Context of this Thesis

Concept	Description	(Guiding) References
Digital Platform Ecosystem	"[A] digital platform ecosystem comprises a platform owner that implements governance mechanisms to facilitate value-creating mechanisms on a digital platform between the platform owner and an ecosystem of autonomous complementors and consumers."	(Hein, Schreieck, Riasanow, et al., 2019, p. 90)
Platform Owner	"A *platform owner* is the organization or group of organizations that determine the architecture, governance, and curation mechanisms for the platform."	(Hevner & Malgonde, 2019, p. 407)
Complementor	An autonomous third-party actor on the supply-side of the digital platform ecosystem, interacting with other ecosystem actors and co-creating and capturing value.	(Hein, Schreieck, Riasanow, et al., 2019; Lusch & Nambisan, 2015; R. D. Wang & Miller, 2019)
Complementor Engagement	A complementor's transactional and non-transactional interactions with the digital platform ecosystem and its actors, which form an ongoing iterative process.	(Jacobides et al., 2018; Saadatmand et al., 2019; Verhoef et al., 2010)

3 Research Design

This thesis builds on a constructionist worldview to investigate complementor engagement in digital platform ecosystems. We use a qualitative research strategy and utilize case study research, a literature review, and design science research as our research methods. The subsequent chapters provide the background of our research design.

2.1 Constructionist, Qualitative Research Strategy

We aim to investigate the engagement of complementors in digital platform ecosystems and build on a **constructionist** worldview (Creswell & Creswell, 2018). This worldview follows critical ontological realism combined with epistemological subjectivism (Levers, 2013). Additionally, we follow a qualitative research strategy.

The constructionist worldview assumes that meaning is created through interactions between the researcher and the research object (Crotty, 2015; Levers, 2013). Hence, this view emphasizes the subjective perspective of the observer. Constructionists do not seek an objective account of events but assume the coexistence of different perspectives on the same phenomenon, inclusive of each other and constructed through the interactions and viewpoints of its participants. Researchers who follow constructionist assumptions do not aim to generalize their observations but seek to generate a deep understanding of the phenomenon and inform other settings (Orlikowski & Baroudi, 1991). Constructionist approaches rely on research strategies that allow researchers to study phenomena in their natural contexts. Hence, qualitative research strategies are particularly suitable.

Qualitative research is based on the empirical investigation by using “qualitative data from a variety of sources, such as interviews, observations, design efforts, interventions, and archival materials” (Conboy et al., 2012, p. 113). A qualitative research strategy is appropriate for complex, dynamically evolving phenomena (Corbin & Strauss, 1990). In light of the complexity of digital platform ecosystems and the dynamics of complementors’ engagement within this rapidly evolving context, qualitative research allows for a comprehensive investigation of this phenomenon.

2.2 Research Methods

This thesis draws on three qualitative research methods following a qualitative research strategy. The dominant research method is case study research (P2, P3, P4). Moreover, one study builds on a literature review (P1), while another follows Design Science Research (P5). Table 4 provides an overview of all embedded publications and applied research methods.

Table 4. Overview of Applied Research Methods in the Embedded Publications

No.	Publication Title	Lit. Rev.	Case Study	DSR

P1	Adoption of Software Platforms: Reviewing Influencing Factors and Outlining Future Research	●		
P2	The Engagement of Complementors and the Role of Platform Boundary Resources in e-Commerce Platform Ecosystems		●	
P3	Managing the Interpretive Flexibility of Technology: A Case Study of Celonis and its Partner Ecosystem		●	
P4	Partner Programs and Complementor Assessment in Ecosystem Governance: A Multiple-Case Study		●	
P5	Supporting Partner Management in Enterprise Digital Platform Ecosystems – A Design Science Research Study			●

Legend:
● Method used in the publication
Lit. Rev.: Literature Review
DSR: Design Science Research

Literature Review

The literature review is one of the fundamental steps in any research project, allowing researchers to "stand on the shoulders of giants" and make contributions beyond what is already known in a particular field. Therefore, defining and analyzing the relevant prior work for a topic requires a thorough, structured literature review to reconstruct the giant (Vom Brocke et al., 2009). In addition, the review of relevant literature allows the identification of trends, gaps, and opportunities for future work (Leidner, 2018). Schryen et al. (2021) distinguish two knowledge-building activities: backward and forward-oriented. Backward-oriented knowledge-building activities aim to summarize what is already known, while forward-oriented activities focus on identifying gaps, tensions, and opportunities for future inquiries.

Various contributions provide guidelines for conducting structured literature reviews (e.g., Webster and Watson (2002)) and documenting them to increase their reliability and prove their validity (e.g., Vom Brocke et al. (2009)).

In their seminal editorial in Management Information Systems Quarterly (MISQ), Webster and Watson (2002) propose two steps on *how* to conduct structured literature reviews:

- <u>Step 1: Determine the source material for the review</u>
  Identifying the relevant contributions to a particular topic is the first step in a structured literature search process. This step comprises the selection of relevant outlets, starting with key journals and adding relevant academic conferences. Webster and Watson (2002) stress the importance of looking for relevant papers outside the IS discipline. IS researchers may find these in economics, computer science, strategy and management, and organizational research. Selecting high-quality outlets in each of these disciplines is paramount for an adequate review. This procedure results in the first set of relevant articles. Next, a backward search of relevant articles cited within the first set deepens the literature review, adding a second set of articles. After that, forward searches allow finding articles citing the relevant articles from sets one and two that should be included in the review.

- <u>Step 2: Structure the literature review</u>
  When presenting the insights from literature reviews, Webster and Watson (2002) stress the value of being concept-centric as compared to being author-centric. Using tools such

as concept matrices to present the concepts used in different articles and augmenting these matrices with additional levels of analysis reveals the most important insights from literature reviews.

In addition to conducting literature reviews rigorously, their documentation is of utmost importance, as stressed by Vom Brocke et al. (2009). Detailed descriptions of the search process allow readers to evaluate the strengths and weaknesses of the review and its overall quality in terms of its rigorousness. The authors add to the two overarching steps from Webster and Watson (2002), proposing a more detailed model comprising additional steps such as selecting the database and keywords (see Figure 3).

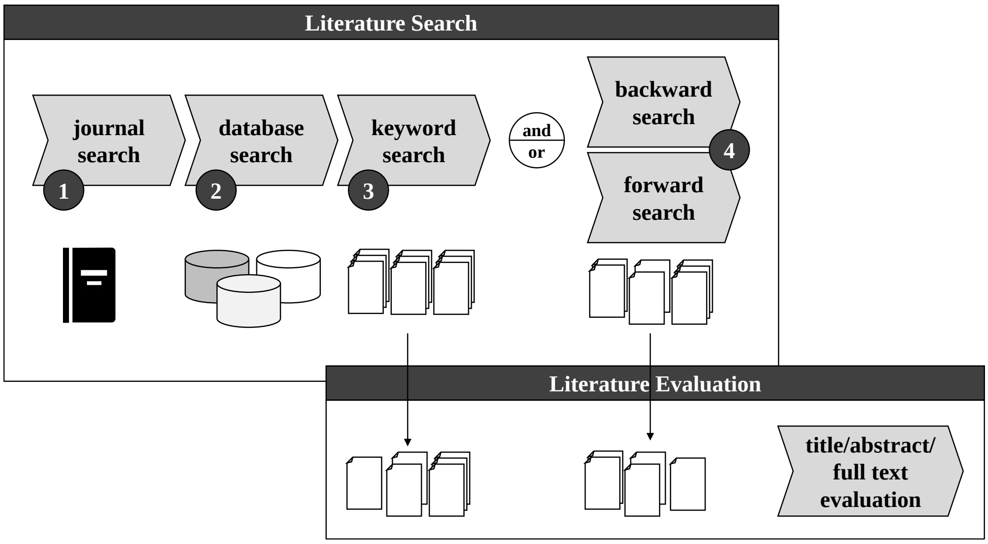

Figure 3. Literature Search Process *(Vom Brocke et al., 2009)*

The embedded publication "*Adoption of Software Platforms: Reviewing Influencing Factors and Outlining Future Research*" (P1) leverages a structured literature review according to the guidelines proposed by Webster and Watson (2002) and Vom Brocke et al. (2009). Using the literature review, P1 uncovers different factors influencing complementors' and users' adoption decisions in software platform ecosystems. Moreover, the reviews provided essential insights into developing an agenda for future work. In addition, we utilized literature reviews in all the remaining publications (P2 to P5) to create the respective relevant knowledge basis from which we developed and positioned our contributions.

Case Study Research

Case study research is a mode of inquiry that allows researchers to create "rich, empirical descriptions of particular instances of a phenomenon" or build theory using different data sources (Eisenhardt & Graebner, 2007, p. 25; Yin, 2018). Importantly, case study research consists of a trilogy: Case study research describes a mode of inquiry, case studies are the research method, while the case is usually the unit of inquiry (Yin, 2018).

The theory development process from case studies is typically inductive and emerges from the constructs, patterns, and connections (Eisenhardt & Graebner, 2007). To develop a powerful theory, "a case study examines a phenomenon in its natural setting, employing multiple methods of data collection to gather information from one or a few entities (people, groups, or organizations). The boundaries of the phenomenon are not clearly evident at the outset of the research, and no experimental control or manipulation is used.” (Benbasat et al., 1987, p. 370).

The procedure of conducting case study research comprises six linear but iterative steps to be performed (see Figure 4).

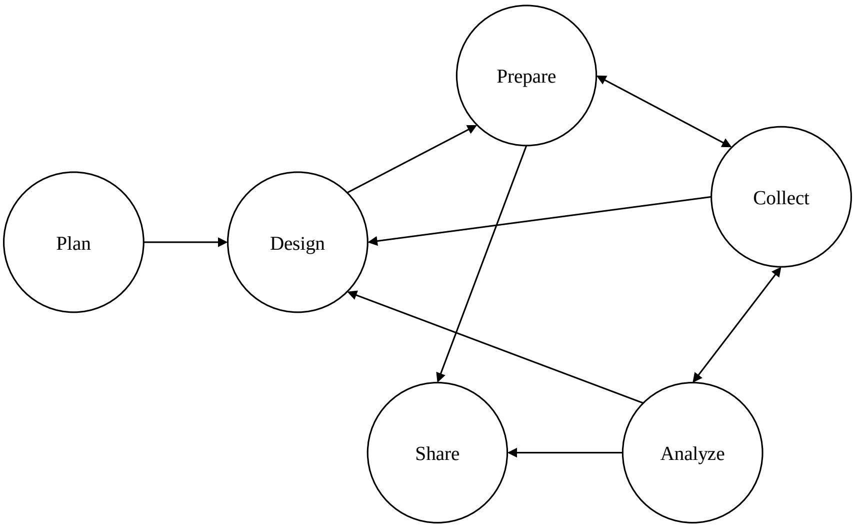

Figure 4. Steps in Case Study Research *(Yin, 2018)*

During the initial *planning* phase, researchers need to determine if case study research is suitable for the phenomenon at hand and the respective research purpose, i.e., the research question guiding the endeavor (Yin, 2018). Benbasat et al. (1987) stress the usefulness of case study research to answer “how” and “why” questions, as they focus on the causal and operational interrelations among entities.

The subsequent *design* phase requires researchers to consider the cases to be studied in light of the study’s goals. The type and number of cases and level of analysis have implications for the findings' generalizability (Yin, 2018). However, access to the case study data is a decisive element to be considered. Yin (2018) differentiates four case study designs (see Figure 5).

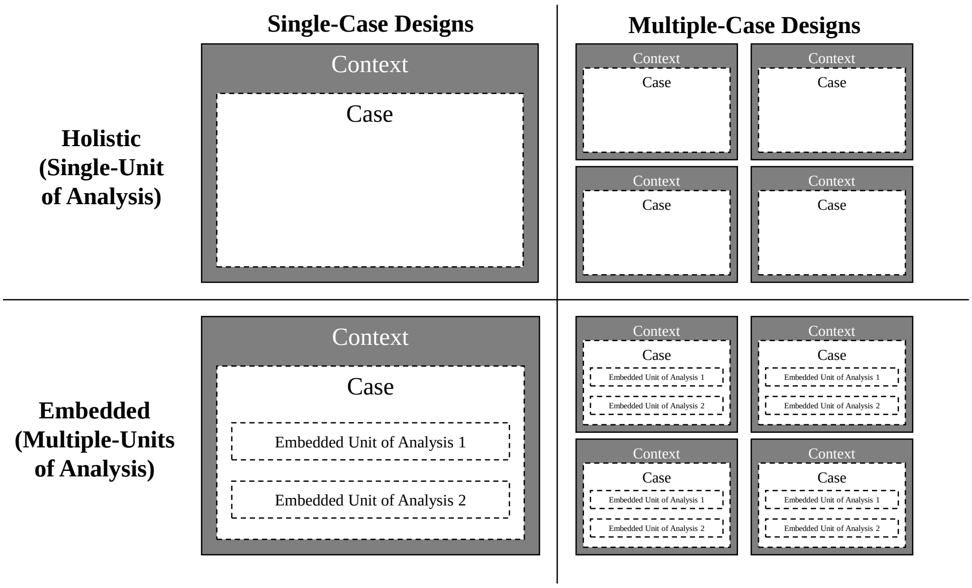

Figure 5. Different Case Study Designs *(Yin, 2018)*

When *preparing*, researchers create the tools and information necessary for collecting data from various sources and decide on the course of action regarding theoretical sampling (Eisenhardt, 1989; Yin, 2018). This step comprises creating interview guidelines, templates, and other materials that facilitate collection and analysis.

Collecting the data for case study research requires researchers to conduct interviews, collect internal and external documents, and make observations, sometimes as part of ethnographies (Yin, 2018). This step may also comprise quantitative data collected via small-scale surveys. The triangulation of the data by using various data sources for the same study helps to mitigate biases and create a comprehensive understanding of the phenomenon under study (Paré & Elam, 1997).

The *analysis* of case data follows a general analytical but fuzzy process and comprises different analytical techniques. Analyzing case study data comprises any combination of categorizing, visualizing, testing, and recombining the available data to search for patterns, insights, and concepts (Yin, 2018). Frequently, researchers rely on coding procedures such as open, axial, and selective coding to arrive at their contribution (Wiesche et al., 2017).

Lastly, the case study results are being *shared* with researchers and practitioners via written and oral compositions (Yin, 2018). The use of visualizations of the results and procedures (e.g., Gioia et al. (2013)) and the methodological processes helps the audience to understand and build upon the results of case study research. During this step, the research team has to make decisions concerning anonymity and actively seek feedback on the presentation of the case.

The embedded publication *"The Engagement of Complementors and the Role of Platform Boundary Resources in e-Commerce Platform Ecosystems"* (P2) builds on a single-case study in the context of e-commerce CMSs. We chose three content management system platform ecosystems as the embedded units of analysis. We employed theoretical sampling to identify platform ecosystems with different ownership states. In addition, the embedded publication

"Managing the Interpretive Flexibility of Technology: A Case Study of Celonis and its Partner Ecosystem" (P3) analyses the case of Celonis, which represents an extreme case due to its growth trajectory during the last decade. Lastly, the embedded publication *"Partner Programs and Complementor Assessment in Ecosystem Governance: A Multiple-Case Study"* (P4) utilizes a multiple-case study design. The results are presented using a taxonomy comprising criteria and metrics platform owners use to assess complementors.

Design Science Research

DSR is a *"research activity that invents or builds new, innovative artifacts for solving problems or achieving improvements, i.e. DSR creates new means for achieving some general (unsituated) goal, as its major research contributions. Such new and innovative artifacts create new reality, rather than explaining existing reality or helping to make sense of it."* (Ilivari & Venable, 2009, p. 3). Hence, the artifact, its creation, and its evaluation are at the center of DSR. Artifacts can take different forms, such as constructs, models, methods, and instantiations, including prototypes (Österle et al., 2011). While the artifact is its focal object, DSR also contributes to theory by generating descriptive and prescriptive knowledge (Gregor & Hevner, 2013).

Conducting DSR follows an iterative process. Over time, researchers have proposed different steps and process models for conducting DSR (e.g., Hevner et al. (2004), Peffers et al. (2007), Österle et al. (2011)). At their core, all DSR processes comprise variations of the four process steps articulated by Österle et al. (2011): Analysis, design, evaluation, and diffusion. Peffers et al. (2007) introduce one popular approach (see Figure 6).

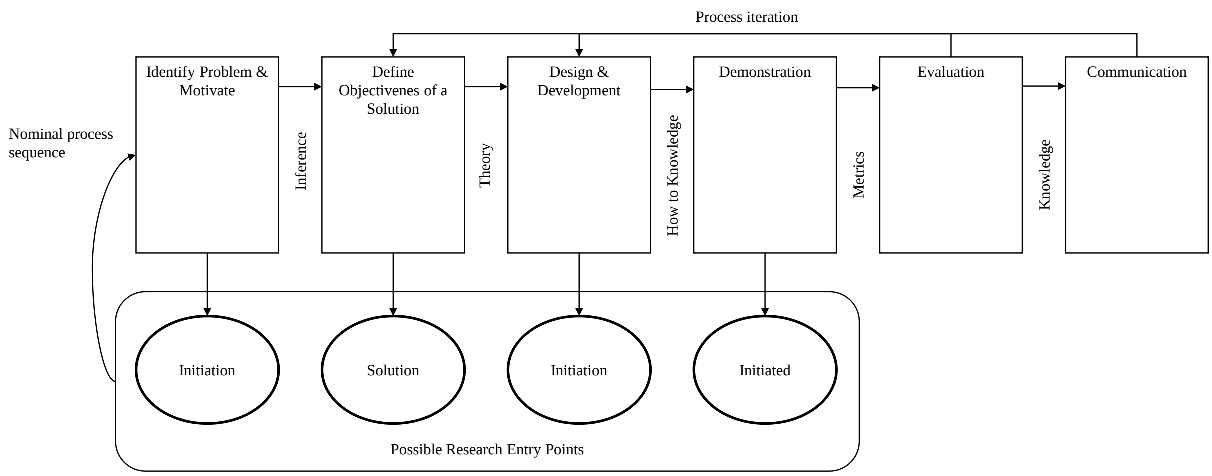

Figure 6. Design Science Research Cycle *(Peffers et al., 2007)*

In the embedded publication *"Supporting Partner Management in Enterprise Digital Platform Ecosystems – A Design Science Research Study"* (P5), we apply DSR according to the guidelines proposed by Hevner et al. (2004). We develop a tool to support platform owners' partner managers with their different tasks based on interviews with potential users. We further evaluate the artifact through a simulation (Venable et al., 2016).

Part B

1 Adoption of Software Platforms: Reviewing Influencing Factors and Outlining Future Research

Table 5. Fact Sheet Publication P1

Authors	Engert, Martin[1] (engert@fortiss.de) Pfaff, Matthias[1] (pfaff@fortiss.de) Krcmar, Helmut[1,2] (krcmar@in.tum.de) [1]fortiss GmbH, Guerickestraße 25, 80805 Munich, Germany [2]Technische Universität München, Chair for Information Systems, Boltzmannstraße 3, 85748 Garching, Germany
Outlet	Pacific Asia Conference on Information Systems (PACIS), 2019
Status	Published
Contribution of First Author	Problem Definition, Research Design, Data Collection, Data Analysis, Interpretation, Reporting

Abstract. Software platforms have received attention as the dominant model for cooperative software development. Growing the ecosystems around software platforms through increasing adoption by users and developers is of great importance for platform owners. However, there is a lack of research on how to increase adoption and growth of software platforms systematically. To address this issue, we conduct a literature review and make an in-depth analysis to uncover and organize factors that drive adoption of software platforms. Additionally, we derive effective directions of these factors on the respective sides. Finally, we outline three avenues for future research: aligning research on platform governance and platform launch and growth, taking an evolutionary, growth-oriented perspective on governance of software platforms and further detailing platform launch and growth strategies towards a design theory for platform launch. This paper contributes to the understanding of software platforms by reviewing factors driving adoption and triggering network effects.

2 The Engagement of Complementors and the Role of Platform Boundary Resources in e-Commerce Platform Ecosystems[2]

Table 6. Fact Sheet Publication P2

Authors	Engert, Martin[1] (martin.engert@tum.de) Evers, Julia[1] (ga94woy@mytum.de) Hein, Andreas[1] (andreas.hein@tum.de) Krcmar, Helmut[1] (krcmar@tum.de) [1]Technische Universität München, Chair for Information Systems, Boltzmannstraße 3, 85748 Garching, Germany
Outlet	Information Systems Frontiers (ISF), 2022
Status	Published
Contribution of First Author	Literature Review, Problem Definition, Research Design, Interpretation, Reporting

Abstract. The success of digital platforms can be attributed to the engagement of autonomous complementors as exemplified by e-commerce Content Management System (CMS) platforms such as WordPress and Shopify. Platform owners provide Platform Boundary Resources (PBRs) to stimulate and control complementor engagement. Despite the increasing scholarly interest on digital platform ecosystems, their exact role in facilitating and channeling complementor engagement remains unclear. Therefore, we conducted an embedded case study on CMS platform ecosystems, comprising a total of 24 interviews with platform owners and complementors. We inductively derive five types of complementor engagement and their respective manifestations and two overarching engagement goals of complementors. Moreover, we determine the different types of PBRs utilized, including their critical effects, and distinguish between uniform and individual PBRs reflecting their respective generalizability and scalability. We discuss the findings by introducing the concepts of complementor resourcing and complementor securing and shed light on the standardization-individualization tension of PBRs faced by platform owners.

3 Managing the Interpretive Flexibility of Technology: A Case Study of Celonis and its Partner Ecosystem

Table 7. Fact Sheet Publication P3

Authors	Engert, Martin[1] (martin.engert@tum.de) Yifang Chu[1,2] (chu@celonis.com) Hein, Andreas[1] (andreas.hein@tum.de) Krcmar, Helmut[1] (krcmar@tum.de) [1] Technische Universität München, Chair for Information Systems, Boltzmannstraße 3, 85748 Garching, Germany [2]Celonis SE, Theresienstrasse 6, 80333 Munich, Germany
Outlet	International Conference on Information Systems (ICIS), 2021
Status	Published
Contribution of First Author	Literature Review, Problem Definition, Research Design, Interpretation, Reporting

Abstract. IT artifacts as embodiments of digital technologies are perceived differently by different user groups – a characteristic denoted as the technology's interpretive flexibility. As emphasized in prior contributions, social and technological factors shape the different outcomes of the focal technology. What is less clear is how technology firms can manage and exploit the interpretive flexibility of their technology to maximize their value potential while adequately addressing their (potential) customers' needs. This ongoing study aims to investigate the mechanisms technology providers use to strike that balance individually and collectively. Between 2018 and 2021, we conduct an in-depth case study of Celonis the market leader in process mining, and develop a preliminary model for managing the interpretive flexibility of technology. Focusing on Celonis' efforts to create a partner ecosystem around its core technology, we find two basic mechanisms through which partners increase (deployment) or decrease (abstraction) the interpretive flexibility of Celonis' technology.

4 Partner Programs and Complementor Assessment in Ecosystem Governance: A Multiple-Case Study

Table 8. Fact Sheet Publication P4

Authors	Engert, Martin[1,2] (engert@fortiss.de) Hein, Andreas[2] (andreas.hein@tum.de) Krcmar, Helmut[1,2] (krcmar@tum.de) [1]fortiss GmbH, Guerickestraße 25, 80805 Munich, Germany [2]Technische Universität München, Chair for Information Systems, Boltzmannstraße 3, 85748 Garching, Germany
Outlet	Americas Conference on Information Systems (AMCIS), 2020
Status	Published
Contribution of First Author	Literature Review, Problem Definition, Research Design, Data Collection, Data Analysis, Interpretation, Reporting

Abstract. Digital platform ecosystems are an omnipresent phenomenon. Compared to traditional modes of interaction, digital pltaforms rely on complementary produts and services that autonomous partners provide . However, adequate measures to assess the output of complementors are not readily available and lack theoretical grounding. Thus, the goal of this paper is to explore and organize criteria and related metrics for the assessment of complementor outputs. We conduct a multiple-case study on 14 partner programs of B2B software platforms. Then, we develop a taxonomy comprising different complementor outputs in digital platform ecosystems. The taxonomy comprises 26 criteria for two complementor roles and respective metrics applied by platform owners for their evaluation. Furthermore, we describe characteristics of partner programs such as variations in assessment modes and intervals. Our findings support platform owners when creating and updating their partner programs and provide the basis for future work on the assessment of complementor ouput.

5 Enabling Partner Management in Enterprise Platform Ecosystems - A Design Science Research Study

Table 9. Fact Sheet Publication P5

Authors	Engert, Martin[1] (martin.engert@tum.de) Fuchs, Jonathan[1] (fuchsjon@in.tum.de) Hein, Andreas[1] (andreas.hein@tum.de) Krcmar, Helmut[1] (krcmar@tum.de) [1]Technische Universität München, Chair for Information Systems, Boltzmannstraße 3, 85748 Garching, Germany
Outlet	Pacific Asia Conference on Information Systems (PACIS), 2021
Status	Published
Contribution of First Author	Literature Review, Problem Definition, Research Design, Data Collection, Data Analysis, Reporting

Abstract. Partner management is an important success factor for digital platform ecosystems. It operationalizes the platform partner strategy, making far-reaching decisions concerning value co-creation and mitigating governance tensions. However, tools to support partner managers in their tasks have received little attention. Using design science research, we develop a tool prototype that is capable of supporting partner managers through computation, provision, and visualization of relevant information. We analyze the literature and conduct nine interviews with partner managers from three enterprise software platform firms to identify requirements in four task areas. This paper presents the first design cycle comprising seven realized requirements. We present and evaluate the IT-artifact using a simulation. Our findings highlight the need for information in platform governance and demonstrate the artifact's ability to address practical needs and provide valuable IT-based decision support. We contribute to the literature on the governance of complementors and support practitioners with an effective tool.

Part C

1 Summary of Results

We address the three research questions through five publications. The following sections summarize the findings of the embedded publications and how they address each research question.

RQ1: *What factors influence complementors' decision to adopt a digital platform ecosystem?*

Adoption decisions of complementors and users follow similar factors. Based on a systematic literature review on software-driven platform ecosystems in IS and strategy and management fields, we identify factors influencing complementors' and users' adoption decisions ***(P1)***. From 69 relevant articles, we uncover 43 factors, which comprise three categories: Universal, semi-universal, and specific factors. Universal factors impact the adoption of both complementors and users directly. Semi-universal factors drive the adoption of both groups directly and/or indirectly. Lastly, specific factors affect adoption for only one of both groups. Crafting growth strategies for digital platform ecosystems needs to consider the impacts for both groups across all factors.

RQ2: *How do complementors engage in digital platform ecosystems?*

Complementors' engagement takes different types, manifestations, and goals. Our embedded case study in the e-commerce context revealed the different interactions and motivations underlying complementor engagement ***(P2)***. The two overarching engagement goals of complementors pertain to ensuring the alignment with the platform and driving their innovation and success. The interactions underlying complementors' engagement follow five different types: developing products, ensuring compliance, enhancing products, commercializing products, and cooperating. According to our case study, each engagement type manifests in two ways, resulting in ten engagement manifestations. These insights underscore the diverse and complex nature of complementor engagement.

Platform boundary resources are an integral part of complementor engagement. Following the results of our case study, each engagement type is associated with the utilization of PBRs ***(P2)***. Two categories emerge from the PBRs utilized by complementors: Uniform and individual PBRs. Uniform PBRs, such as APIs and documentation, are standardized resources offered to all complementors within the platform ecosystem, emphasizing their scalability. Individual PBRs, in contrast, reflect one-to-one or one-to-few resources, including personal contacts or hackathons, which do not scale arbitrarily across the ecosystem. Moreover, complementors' engagement aiming at the alignment with the platform heavily depends on uniform PBRs instead of engagement that aims at individual success, which in most cases depends on individual PBRs. Lastly, our study suggests three critical effects of PBRs: innovation, governance, and communication.

Complementor ecosystems enable managing a technology's interpretive flexibility. The case study on Celonis resulted in developing a conceptual model for managing the interpretive flexibility of technology ***(P3)***. Based on interviews with Celonis representatives between 2018 and 2021, the study uncovers how Celonis managed its process mining technology. It interprets Celonis' different activities and adjustments through the lens of interpretive flexibility of technology. The study results suggest two mechanisms through which complementors can increase or decrease a technology's interpretive flexibility. First, they engage in *deployment* when using the technology, enriching it with their expertise and applying it to customer problems. Second, when developing applications for the application marketplace from successful customer projects, they engage in *abstraction*. The results suggest that platform owners can motivate and guide these complementary activities through partner enablement mechanisms, which bridge part of the gap between the underlying technology and customers' needs.

RQ3: *How can platform owners use information to manage complementor engagement in digital platform ecosystems?*

Partner programs are institutionalized information-based management systems. Based on our analysis of 14 partner programs in the context of enterprise software platform ecosystems, we uncover these programs' key characteristics and main elements ***(P4)***. In essence, partner programs are institutionalized assessment systems for platform owners to generate information on partners individually and collectively and prescribe the consequences of the assessment. To that end, partner programs define the different criteria and associated metrics for each criterion through which complementors are being assessed. According to our results, these programs further define the mechanisms through which platform owners sort complementors into tiered groups. Lastly, partner programs determine the benefits for complementors in each group, systemizing the access for complementors to specific resources and individual support.

Strategic and operational tasks of platform partner management. Using qualitative interviews, we investigated partner managers' tasks and information needs in the enterprise software context ***(P5)***. We determine their strategic and operational tasks by inquiring about partner managers from three platform firms. Strategic tasks comprise the management of individual partner managers, developing and executing an overarching partner management strategy for the platform owner in different regions and partner types. Moreover, managing the overall partner network comprises strategic and operational elements, such as qualifying and educating additional partners. The partners' comparison and ranking is another task that combines strategic and operational aspects, as data needs to be gathered and evaluated based on pre-defined KPIs. Lastly, managing individual partners within the overarching partner management framework is a primarily operational task, including regular check-ins, reviews and support. These insights emphasize the importance of partner managers in defining and executing the platform's partner-related governance rules and mechanisms.

Provision of relevant information for partner management tasks via a web-based tool. Using DSR, we developed a tool to address the information needs of partner managers in the enterprise software context ***(P5)***. Based on interviews with partner managers, we derive seven requirements. The main requirement is the analysis and evaluation of partners based on KPIs. Other requirements relate to ranking, visualization, time-series, prediction, and customization of views. We derive seven design principles from the requirements and develop a tool prototype centered around different customizable dashboards to visualize partner-related information such as KPIs. The artifact utilizes state-of-the-art technologies, including microservices, DevOps support, and web access. Lastly, we evaluate the prototype using scenario-based simulation concerning its utility in supporting the different partner management tasks.

Table 10. Overview of Key Results

P	RQ	Findings
P1	RQ1	▪ Sixteen factors impact complementors adoption decisions exclusively. Nineteen factors impact complementors' and users' adoption decisions. ▪ Three categories of factors impact digital platform ecosystem growth: Universal, semi-universal, and specific. ▪ Many of the factors impact complementors' adoption decisions and users' adoption. They are interlinking their adoption decisions and impacting the design of platform growth strategies. ▪ There are three suggestions for future work on the alignment of research on platform governance and platform launch and growth, towards an evolutionary perspective on platform governance, and the development of a design theory of platform launch.
P2	RQ2	▪ Identification of two engagement goals for complementors: They engage to ensure alignment with the platform and drive innovation and success. ▪ Related to the engagement goals, we describe five engagement types, each comprising two engagement manifestations, highlighting the multidimensional nature of complementors' engagement. - Developing products manifests through technical integration and addressing technical requirements to align with the platform. - Ensuring compliance manifests through legal and regulatory compliance to align with the platform. - Enhancing products manifests through troubleshooting and technical requests to drive innovation and success. - Commercializing products manifests through customer outreach and competitive differentiation to drive innovation and success. - Cooperating manifests through knowledge exchange and platform co-development to drive innovation and success. ▪ PBRs are essential interfaces to allow and support complementor engagement. All engagement types utilize PBRs. ▪ PBRs are either uniform or individual, reflecting their standardized (i.e., one-to-many) and customized (i.e., one-to-one or one-to-few) nature and availability. ▪ PBRs have three critical effects in supporting and motivating complementor engagement: Innovation-orientation, governance orientation, and communication orientation. ▪ Complementors engage in resourcing and securing activities, thereby tuning PBRs.
P3	RQ2	▪ A conceptual model to illustrate and analyze the management of interpretive flexibility of technology and its relation to the value derived for customers and the technology firm. ▪ Technology firms engage partner ecosystems to manage the interpretive flexibility of their technologies. ▪ Complementors engage in two mechanisms to increase and decrease the interpretive flexibility of the platform technology. ▪ Abstraction describes a process in which complementors build general applications on the platform technology for the application marketplace from successful customer projects. ▪ Deployment describes a process in which complementors use the platform technology in customer projects, enriching the technology with their skills and expertise.
P4	RQ3	▪ Partner programs are institutionalized assessment systems for complementors. ▪ Platform owners use partner programs to define assessment criteria and associated KPIs, allowing them information-based management of complementors individually and collectively. ▪ Partner programs differ according to their defined partner roles, assessment intervals, assessment modes, and partner levels. ▪ Using the information created through the ongoing assessment, platform owners sort partners into tiers, which again are associated with pre-defined benefits and support.
P5	RQ3	▪ The management of partners comprises different strategic and operational tasks to balance different governance tensions and implement the platform's partner-related strategy. ▪ Fulfilling these tasks requires adequate information to be provided to partner managers in real-time. ▪ A prototype of a web-based tool comprising a dashboard-based architecture to support the evaluation and visualization of information on partners individually and collectively. ▪ The prototype comprises users' customization features according to their tasks and preferences. ▪ Evaluation of the prototype using scenario-based evaluation.

2 Discussion and Theoretical Implications

From the results of this dissertation, we discuss the findings in light of extant research. First, we discuss the shift in perspective from adoption to the engagement of complementors in digital platform ecosystems. Second, we reflect on the role of complementors and their engagement from the perspective of platform owners of digital technology platforms. Lastly, we conceptualize information capabilities for platform owners and the implications of information-based ecosystem management.

2.1 From Adoption Decision to Continuous Complementor Engagement

Based on the results of our studies, complementors' decision to adopt a platform ecosystem only represents the starting point of their engagement journey ***(P1, P2)***. Much of the research on platform ecosystems and multi-sided markets was developed around the idea of increasing the adoption of platform ecosystems by complementors (J. Song et al., 2018). A critical topic for platform research focused on launch and growth strategies for platform ecosystems and the issues of attracting large numbers of users and complementors (e.g., Evans and Schmalensee (2010) and De Reuver, Nederstigt, and Janssen (2018)).

However, McIntyre et al. (2021) point out that for platforms to persist, they need to engage complementors continuously. This new perspective goes beyond complementors binary decision to adopt a platform but toward sustained engagement of complementors and the platform's evolution (O'Mahony & Karp, 2022).

The results of our literature review provide the basis for understanding the complexity underlying complementors' adoption decisions based on insights from prior studies ***(P1)***. The study highlights multiple facets to be considered to attract complementors. Building on these insights, our case study on three content management systems in the context of e-commerce platforms expands on these results ***(P2)***. The study examines how complementors engage with the platform ecosystem in different ways. We provide empirical evidence on five different manifestations of complementor engagement, highlighting its diverse nature.

Our studies contribute to a change in perspective for platform owners and complementors. First, platform owners are challenged beyond attracting many complementors to their platforms but continuously manage diverse interactions throughout the platform lifecycle. These results resonate with various scholars' suggestions to take a dynamic stance toward platform governance (O'Mahony & Karp, 2022; Schreieck et al., 2016, 2021). Second, the results indicate the complexity of complementor strategies, with decisions going beyond the initial adoption decision but including continuous adaptation and strategic resource investments (Cenamor, 2021; R. D. Wang & Miller, 2019).

2.2 A Market-based Perspective on Managing Technology Platforms

The study on the technology firm Celonis conceptualized a model (see Figure 7) to manage the interpretive flexibility of technology ***(P3)***. This new perspective centers around a value-based technology perspective, reflecting customers' market needs and providers' opportunities. According to the proposed view, technology can take a concrete state (i.e., having low interpretive flexibility), where it is directly applicable to a particular (customer) problem without further adjustment, thus embodying high value for its users. Or, it can take a more generic state (i.e., having high interpretive flexibility), where it is applicable to a broad set of problems but needs further refinement to be effective, thus embodying high value for the technology firm and its market potential.

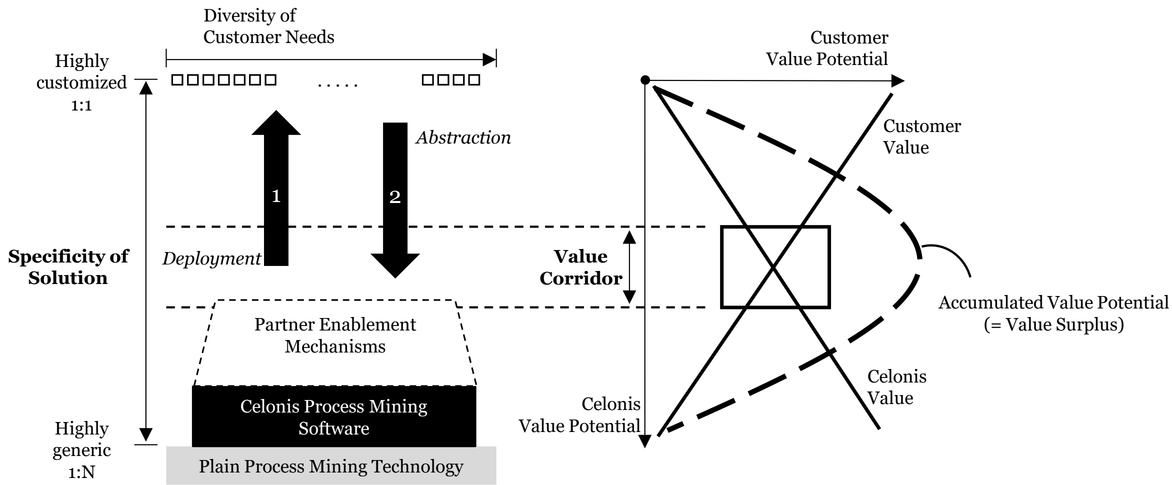

Figure 7 Framework for Managing the Interpretive Flexibility of Technology *(Engert, Chu, et al., 2021)*

This view represents a market-based perspective of managing technologies. It unveils a dilemma technology firms face in customizing or generalizing their proprietary technology. Researchers have suggested users could customize a given technology for their purposes; however, technologies need to be designed to be tailorable (e.g., Germonprez et al. (2007)), again foreclosing specific application spaces and limiting generalization. On the other hand, broadly applicable solutions have high interpretive flexibility, and users need support to reap the technology's benefits (e.g., Doherty et al. (2006)).

Our study ***(P3)*** introduced the value corridor into the field of tension between the two poles to address this dialectic tension. It emphasizes that the cumulative value derived from a given technology is the highest when the technology is balanced between a customized and general state. Managing a technology's positioning within the value corridor is the resulting challenge for technology firms. Technology firms' operational and strategic decisions affect the positioning of a focal technology between the two poles – and inside or outside the value corridor.

Our research shows that platform firms need to acknowledge this tension along the evolutionary trajectory of the technology and the platform ecosystem. Our model allows the planning and analysis of different strategic moves, including technology, product, and market decisions, but also when and how to employ third-parties. Complementor ecosystems play a pivotal role in striking a balance and answering the customization-generalization dilemma. We encourage researchers to utilize and expand the proposed model.

2.3 Towards an Information Capability of Platform Owners

Several of our studies emphasize and explore the role of information for platform owners to manage complementor engagement. For instance, deploying universal or individual PBRs and their collective tuning together with complementors hinges on the availability of adequate information on their use ***(P2)***. Moreover, the analysis of partner programs in the enterprise software industry revealed that metrics and KPIs play an essential role in managing complementors individually and collectively ***(P4)***. Furthermore, as the operative and strategic interface of the platform owner with complementors, partner managers rely on the availability of information, which they use to create and execute their tasks appropriately ***(P5)***. Thus, the *provision* and *exploitation* of information to manage complementor engagement in digital platform ecosystems require an information capability for platform owners.

Similarly, extant research on platform ecosystems has identified the need for adequate information for platform firms and their management (Hinz et al., 2020; Leong et al., 2019). Fotrousi et al. (2014) identified metrics and KPIs ranging from individual and collective performance to interoperability and heterogeneity. Moreover, Plakidas et al. (2017) provide an extensive analysis of the R software ecosystem using various metrics. Lastly, several contributions have assessed the health of platform ecosystems using network-based analysis (Hyrynsalmi & Mäntymäki, 2018; Iansiti & Levien, 2002; Jansen, 2014). While these studies emphasize the applicability and usefulness of assessment approaches in platform ecosystems, how platform owners can create and utilize information to manage their platform ecosystems dynamically remains unclear. Hence, to date, a comprehensive understanding of complementors' engagement and how information can support platform owners' dynamic decision-making is missing.

The ability "[...] to provide quality information with appropriate levels of detail, relevance, reliability, and timeliness […]" is denoted as *information capabilities*, emphasizing the *provision* of information (Kulkarni et al., 2017, p. 519). Additionally, the use of information requires the ability "[...] to manage and exploit information [...]", reflecting the *adequate use* of available information. Organizations need both abilities for effective decision-making(Cao et al., 2019). Therefore, integrating both aspects, platform owners' information capabilities *comprise the ability to provide, manage, and exploit information with appropriate detail, relevance, reliability, and timeliness.* Based on this definition, platform owners' information capabilities create valuable insights on *what decisions* to take and *how effective* these measures have been.

The ecosystem's variety and the number of complementors challenge the platform owner to balance individual and collective management (Huber et al., 2017) and enact flexibility and benevolence in practicing the associated rules (Hurni et al., 2021). In addition, tensions arise from enabling generativity while ensuring stability (Tilson et al., 2010) or balancing cooperative and competitive approaches (Eaton et al., 2015; Foerderer, 2017; Halckenhaeusser et al., 2020b). Platform owners and, more precisely, partner managers need to decide how to balance these tensions operatively and strategically. Furthermore, they must monitor their adjustments and respond to the dynamics inside and outside the ecosystem ***(P5)***. As a result, platform governance and PBR design are dynamically adapted to the evolution and contingencies of the ecosystem, creating a need to monitor activities continuously (Cennamo & Santalo, 2019; Wareham et al., 2014).

Based on the insights from the embedded publications, we comprehensively understand complementor engagement and the interplay with the platform owner's information capability and dynamic management decisions. Essentially, assessing complementors and their engagement via information capabilities is a prerequisite for effective design and ongoing governance in digital platform ecosystems, as depicted in Figure 8.

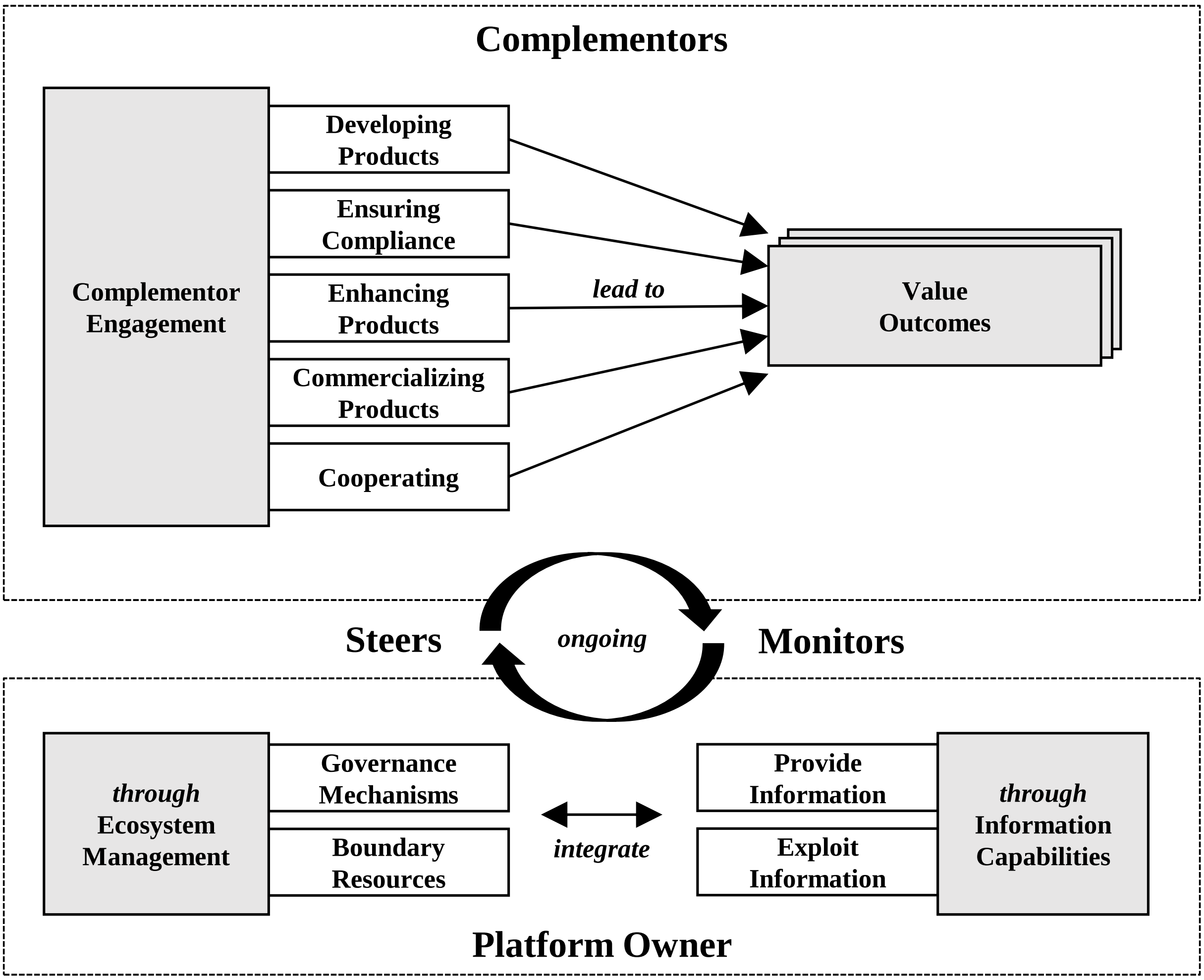

Figure 8. Complementor Engagement and its Continous Management through Information Capabilities

Figure 8 integrates our findings on complementor engagement and its manifestations ***(P2)*** and the process of iterative steering and monitoring of complementor engagement by the platform owner ***(P3, P4, P5)***. Platform owners build on information capabilities and various means for platform management, including platform governance and platform PBRs.

At its core, the model proposes an ongoing cycle of monitoring and steering complementor engagement, allowing platform owners to assess their ecosystem of complementors individually and collectively over time. The current thesis provides detailed insights into the different types of complementor engagement, ranging from product development to cooperating with their peers ***(P2, P3)***. All complementor engagement types lead to value outcomes for various stakeholders. First, our results inform complementors' monitoring activities by supporting the development of adequate criteria and metrics to provide relevant information ***(P4)***. Second, to exploit this information, suitable criteria and metrics are integrated into individual and collective assessment and management approaches, such as partner programs ***(P4)*** or partner managers ***(P5)***. Besides governance mechanisms, different PBRs ***(P2, P3)*** design allows platform owners to manage the complementor ecosystem, thus steering complementor engagement in future iterations.

In summary, information capabilities support platform owners in monitoring ecosystem activities and subsequent decision-making through the ability to provide, manage, and exploit relevant information.

While prior work has investigated and described various capabilities for platform owners. In their study of the SAP platform ecosystem, Schreieck et al. (2021) identify cloud-based platformization, open IT landscape management, ecosystem orchestration, platform evangelism, and platform co-selling capabilities. Similarly, Blaschke et al. (2018) find four capabilities that support platform owners in balancing generativity and control, which comprise system orchestration, system reformation, ecosystem preservation, and ecosystem diversification capabilities. Lastly, based on a dynamic capability perspective, Helfat and Raubitschek (2018) describe three types of dynamic capabilities for platform owners, ranging from innovation capabilities and scanning/sensing capabilities to integrative capabilities.

The proposed capabilities by Schreieck et al. (2021) (i.e., ecosystem orchestration) and Blaschke et al. (2018) (i.e., system orchestration, ecosystem preservation, ecosystem diversification) reflect the platform owner's ability to manage the ecosystem as depicted in Figure 8. In addition, the findings of Helfat and Raubitschek (2018, p. 5) indicate the necessity of the platform owner’s ability to scan and sense for “new opportunities” and gain “feedback from customers.” However, the ability to create and utilize adequate and up-to-date information about the complementor ecosystem remains unaccounted. Our empirical studies highlight the needs and strategies of platform owners to provide, manage and exploit information for their ecosystem management ***(P4, P5)***. We denote their ability to do so as their *information capability*.

Integrating a platform owner’s information capability with its ecosystem management capabilities described by extant work requires careful consideration of interdependencies and cause-effect relationships within digital platforms, posing exciting opportunities for future work as suggested by Floetgen et al. (2021).

3 Implications for Practice

The insights from this dissertation have direct implications for digital platform ecosystems. We provide practitioners in platform owner and complementor roles with actionable recommendations.

First, we focus on **complementor engagement** vis-à-vis the traditional notion of platform adoption ***(P1)***. We provide insights into *how* complementors engage with platform ecosystems, accentuating a dynamic and temporal perspective while stressing the complexity of complementors' interactions. This is crucial since platform firms, particularly platform-based startup companies, focus on attracting users and complementors but tend to invest fewer resources in engaging existing complementors. We show ***(P2)*** that platform PBRs are vital elements in motivating and governing complementor engagement and its various manifestations. By providing an extensive overview of engagement goals and manifestations, we inform platform owners of the possibilities arising from complementary engagement. Further, focusing on the diversity underlying complementors' engagement, we highlight the opportunities for complementors to diversify their engagement within and across platform ecosystems, balancing their resources accordingly.

Second, we provide two distinct categories of platform PBRs concerning **platform boundary resources design**. Our study on e-commerce content management systems distinguishes uniform and individual PBRs ***(P2)***. We provide complementors with an extensive outline of possibilities to utilize PBRs for different purposes. In practice, platform owners need to decide on providing resource-intensive individual PBRs or offering more general, uniform PBRs. To support platform owners' decision-making, we further identify three critical effects of PBRs: Innovation-oriented, governance-oriented, and communication-oriented PBRs. Moreover, we present extensive examples to guide platform owners in selecting adequate PBRs to provoke the critical effects at the desired scale.

Third, we offer a **framework for positioning strategies** for technology platforms and their complementors. Our study on the technology firm Celonis conceptualized a model to manage the interpretive flexibility of technology ***(P3)***. Technology platform firms may utilize the proposed model to evaluate decisions that impact their market positioning vis-à-vis current and potential customers. Moreover, platform owners can derive implications on how to engage complementors, for instance, to deliver the platform or create applications as more generalized instantiations of their expertise. In addition, complementors may derive options for positioning themselves as specialists or generalists within the ecosystem.

Fourth, platform owners should adopt **information-based approaches** to managing complementor engagement individually and collectively. Based on our study on partner programs in the enterprise software context, we compose an exhaustive list of criteria to assess complementors ***(P4)***. Platform owners may use these criteria to define tiered categories for complementors, which correspond to complementors engagement levels and the respective support they get from the platform owner. Moreover, we link these criteria to suitable and proven metrics used by successful enterprise software platforms. The metrics allow platform owners to monitor complementor engagement using KPIs. Lastly, complementors may use the metrics to track their performances and achievements or evaluate the partner programs of potential platforms to join.

Fifth, our DSR study developed a prototype for a **partner management dashboard**. The interview-based study resulted in design principles for a customizable dashboard for partner managers in the enterprise software domain ***(P5)***. The open-source prototype can be utilized and adjusted by practitioners. Furthermore, the tool incorporates knowledge of partner managers' different operational and strategic tasks. Thus, we inform new users and educate new partner managers on their tasks and the relevant metrics to be monitored.

4 Limitations

The decisions made during the data gathering and analysis processes are subject to limitations. Each embedded publication discusses the respectively applicable limitations. Nevertheless, some general limitations need to be considered when interpreting the findings of this dissertation. Therefore, we reflect on these limitations and present the techniques to mitigate these issues.

First, the procedures of **data collection** are subject to limitations. First, gathering the relevant articles during the systematic literature review ***(P1)*** has limitations. Relevant studies may not have been included in the literature review on the adoption of platform ecosystems by complementors. One issue could be the choice of keywords, which may exclude relevant synonyms. By using relevant literature as guidance for selecting keywords, (e.g., McIntyre and Srinivasan (2017) and Gawer (2014)), we minimized the chances of missing key terms. Furthermore, we used two predetermined inclusion criteria to guide the process when deciding on relevant articles. Two authors discussed the relevant papers to mitigate subjective bias and ensure the validity of the findings (Vom Brocke et al., 2009). Furthermore, we collected qualitative data through semi-structured expert interviews, which we triangulated with archival data ***(P2, P3, P5)***. By adhering to the eight steps for case study research proposed by Eisenhardt (1989), we ensured the reliability of our findings ***(P2, P3)***.

Second, **data analysis** processes in all publications ***(P1 – P5)*** may be subject to concerns regarding internal validity, which denotes the validity of inferences of causality from the available data. We mitigated this bias by following three iterative coding steps: open, axial, and selective coding (Wiesche et al., 2017). Additionally, at least two authors were involved in the coding process in each embedded publication, reviewing and discussing the categories and refining to reach a consensus by challenging the resulting codes and constructs with insights from prior literature. Lastly, during the double-blind peer review process for all our embedded publications, external reviewers engaged with our research procedures and the resulting insights, helping us to rule out rival explanations.

Third, the **generalizability** from our qualitative data is inherently limited (Yin, 2018). Most of our studies ***(P2 – P5)*** were conducted in the context of enterprise software platform ecosystems and are based on semi-structured. Some of the idiosyncrasies of this context limit the generalizability to other contexts. While complementors engage with platforms in business-to-consumer (B2C) settings, the manifestations of their engagement and the relevant metrics and KPIs will be different. For instance, the numbers for application downloads in B2C contexts such as mobile phones are much higher than in the enterprise software context. Hence, transferring the insights from our study requires careful case-to-case analysis and consideration. Moreover, we evaluated the DSR artifact developed in ***P5*** using analytical, experimental (i.e., scenario-based simulation), and descriptive methods. While simulations are valid methods for evaluating artifact prototypes (Peffers et al., 2007; Venable et al., 2016), the artifact was not implemented and used in practice. These constraints could be addressed in future DSR iterations of the open-source prototype.

5 Future Research

This section presents different avenues for future research in digital platform ecosystems (see Table 11). First, we inform scholars about the opportunities of changing the focus from adoption decisions to the continuous engagement of complementors. Second, we call for research on the autonomy of complementors and how it affects digital platform ecosystems. Third, we shed light on the positioning strategies of platform firms and the tradeoffs they face. Fourth, we illustrate the benefits of advancing research on the programmatic use of (big) data and analytics in digital platform ecosystems. Fifth, future research should advance the development of the tool prototype, fostering the scholarly understanding of practical problems and supporting practitioners in solving complex decision problems.

Table 11. Avenues for Future Research on Embedded Publications

No.	Avenues and Research Question
P1	**Continuous and sustained complementor engagement:** ▪ How does complementor engagement change over time? ▪ What antecedents influence changes in complementor engagement? ▪ What are the implications for dynamic governance approaches? ▪ What are the implications for complementor strategies?
P2	**The autonomy of complementors:** ▪ How do complementors capitalize on their autonomy by collaborating? ▪ What are the consequences of complementors' autonomy on their engagement? ▪ How can platform owners capitalize on complementors' autonomy while staying in control?
P3	**Conceptualizing positioning strategies for platform firms:** ▪ What are relevant dimensions to position digital platform ecosystems? ▪ What are relevant strategic imperatives for platform owners in digital platform ecosystems? ▪ How can platform owners balance tradeoffs among strategic imperatives digital platform ecosystem?
P4	**Programmatic use of (big) data and analytics in digital platform ecosystems:** ▪ What data is available for actors in digital platform ecosystems? ▪ How can platform owners and complementors use the available data to create competitive advantages? ▪ What capabilities are needed by each actor to utilize the available data?
P5	**Extension and practical evaluation of the tool prototype:** ▪ What are additional stakeholders for the complementor dashboard? ▪ What is relevant complementor-related information that they need? ▪ How can information from the dashboard be shared with complementors?

Continuous and sustained complementor engagement. First, our studies highlighted the complex and diverse nature of complementor engagement ***(P1, P2, P3, P5)***. However, taking a temporal perspective, complementor engagement is subject to pro-active and re-active adjustments by complementors. This observation aligns with prior work on platform ecosystems, which has shown that platform governance, resources, or strategy can incite adaptations of complementary activities (e.g., P. Song et al. (2018) and L. Chen et al. (2022)). For instance, Foerderer (2020) finds that platform events encourage participants' knowledge exchanges and foster innovation, and these effects are more pronounced for older and larger firms. Based on these insights, future work should investigate the antecedents that increase or decrease complementor engagement over time while considering the characteristics of complementors. The results will inform future research on platform design, governance, and interdependencies with complementors' interactions and innovation outcomes. In particular, following this proposed future research avenue contributes to our understanding of dynamic governance approaches for platform owners (e.g., Wareham et al. (2014) and Cennamo and Santalo (2019)) and complementor strategies (e.g., Cenamor (2021) and H. Li and Kettinger (2021)).

The autonomy of complementors. Related to deepening our understanding of continued complementor engagement is the aspect of complementors' autonomy in digital platform ecosystems. As autonomous third-parties, complementors can act freely within the boundaries of the platform ecosystem created by the platform owner (Hein, Schreieck, Riasanow, et al., 2019; Leong et al., 2019). To better understand how complementors leverage that autonomy, further research from a complementor perspective is needed. Several studies have indicated that complementors strategize within and across platform ecosystems, impacting their positioning and the overall platform ecosystem (L. Chen et al., 2022; R. D. Wang & Miller, 2019). One way for complementors to capitalize on their autonomy is to collaborate with their peers, enhancing individual and collective outcomes (H. Li et al., 2022; H. Li & Kettinger, 2021). Exploring criteria for selecting appropriate partners to collaborate with and the design and termination of such collaborations among complementors represent fruitful research avenues. Complementor collaborations also raise questions for platform owners and how they can motivate and guide the underlying processes outside their direct sphere of influence (P. Wang, 2021).

Conceptualizing positioning strategies for platform firms. Our case study of Celonis revealed the challenges for platform firms to define the relevant positioning of their platform ecosystem value proposition ***(P3)***. The analysis showed that technology-driven platform firms are challenged to balance their specialization and generalization. Future work in IS should investigate this issue by exploring the strategies available for platform firms to overcome this dynamic tension and strategic paradox. A first step is to explore the dimensions and characteristics underlying this tension to understand root causes and relevant interdependencies. While complementors are a relevant strategic factor to be considered, product offerings, advancements in the core technology, and competitive moves will influence this ongoing process. Based on these insights, strategic guidelines may be formulated from longitudinal studies of technology platforms firms.

The programmatic use of (big) data and analytics in digital platform ecosystems. Metrics help assess the activity and impact of complementors in digital platform ecosystems (Plakidas et al., 2017). Several contributions have described approaches to assess platform ecosystems, including network structures and platform ecosystem health (Iansiti & Levien, 2002; Jansen, 2014). In addition, several of our studies highlight the importance of individual and collective assessment of complementors and suggested metrics for doing so ***(P4, P5)***. As a next step, these metrics need to be combined into systemic and programmatic approaches that build on the large amounts of data available in digital platform ecosystems. These approaches should directly integrate with the strategies of platform owners. These strategies should consider the information needs of complementors by, for instance, motivating complementors to share data by offering advanced insights from individual data integration. Researchers can build on existing business intelligence and analytics capabilities (e.g., Wamba et al. (2017) and Božič and Dimovski (2019)) and contextualize these insights to digital platform ecosystems. It is critical to consider the respective context and regulations to make meaningful contributions (H. Li & Kettinger, 2021).

Extension and practical evaluation of the tool prototype. The developed prototype is a dashboard-based tool for partner managers ***(P5)***. First, future iterations should consider a distinction of complementor roles such as ISVs, consultants, or resellers. Second, researchers should evaluate which other stakeholders within platform firms benefit from real-time information on complementors, such as developers (e.g., API calls by complementors) or sales personnel (e.g., newly added sales opportunities). These additional stakeholders will have specific needs for complementor-related information, contributing to a 360-degree view of the platform ecosystem. Lastly, much of the information gathered will also be relevant to complementors. Another next step is to evaluate the information complementors need and the ways of delivering this information to them.

6 Conclusion

The success of digital platform ecosystems hinges on the engagement of third-party complementors and the management thereof. Therefore, this dissertation advances our understanding of complementor engagement beyond the initial adoption and explores the role of information in managing it. We first gained a thorough understanding of prior work on digital platform ecosystems and collected the factors that influence complementors decision to join. In a second step, we explored complementor engagement in the e-commerce industry and their use of PBRs based on an embedded case study design. Further, studying the software company Celonis and its partner ecosystem, we derive a model for managing platform ecosystems and describe mechanisms through which complementors are being engaged. Third, we inquire about information creation by assessing complementors and their engagement, which revealed suitable criteria and metrics. Leveraging design science, we further develop and evaluate a prototype for a dashboard-based tool to support partner managers' operational and strategic tasks in practice. The results contribute to IS and management research on building persistent platform ecosystems and inform platform owners and complementors on the complexity and opportunities of complementor engagement and its management. We intend to spark future work on complementors, platform strategies, and information-based management of platform ecosystems.

References

Adner, R. (2017). Ecosystem as Structure: An Actionable Construct for Strategy. *Journal of Management*, *43*(1), 39–58.

Baecker, J., Engert, M., Pfaff, M., & Krcmar, H. (2020). Business Strategies for Data Monetization: Deriving Insights from Practice. In *Internationale Tagung Wirtschaftsinformatik: WI 2020,* Potsdam, Germany.

Benbasat, I., Goldstein, D. K., & Mead, M. (1987). The Case Research Strategy in Studies of Information Systems. *MIS Quarterly*, *11*(3), 369–386.

Benlian, A., Kettinger, W. J., Sunyaev, A., & Winkler, T. J. (2018). Special Section: The Transformative Value of Cloud Computing: A Decoupling, Platformization, and Recombination Theoretical Framework. *Journal of Management Information Systems*, *35*(3), 719–739.

Bergvall-Kåreborn, B., & Howcroft, D. (2014). Persistent problems and practices in information systems development: a study of mobile applications development and distribution. *Information Systems Journal*, *24*(5), 425–444.

Bianco, V. D., Myllarniemi, V., Komssi, M., & Raatikainen, M. (2014). The Role of Platform Boundary Resources in Software Ecosystems: A Case Study. *IEEE/IFIP Conference on Software Architecture*, 11–20.

Blaschke, M., Haki, K., Aier, S., & Winter, R. (2018). Capabilities for Digital Platform Survival: Insights from a Business-to-Business Digital Platform. In *Thirty-Ninth International Conference on Information Systems: ICIS 2018,* San Francisco, CA, United States of America.

Bonina, C., Koskinen, K., Eaton, B., & Gawer, A. (2021). Digital platforms for development: Foundations and research agenda. *Information Systems Journal*, *31*(6), 869–902.

Boudreau, K. J. (2010). Open platform strategies and innovation: Granting access vs. devolving control. *Management Science*, *56*(10), 1849–1872.

Boudreau, K. J. (2012). Let a thousand flowers bloom? An early look at large numbers of software app developers and patterns of innovation. *Organization Science*, *23*(5), 1409–1427.

Boudreau, K. J., & Jeppesen, L. B. (2015). Unpaid crowd complementors: The platform network effect mirage. *Strategic Management Journal*, *36*(12), 1761–1777.

Božič, K., & Dimovski, V. (2019). Business intelligence and analytics use, innovation ambidexterity, and firm performance: A dynamic capabilities perspective. *Journal of Strategic Information Systems*, *28*(4), 101578.

Cao, G., Duan, Y., & Cadden, T. (2019). The link between information processing capability and competitive advantage mediated through decision-making effectiveness. *International Journal of Information Management*, *44*, 121–131.

Ceccagnoli, M., Forman, C., Huang, P., & Wu, D. J. (2012). Cocreation of Value in a Platform Ecosystem: The Case of Enterprise Software. *MIS Quarterly*, *36*(1), 263–290.

Cenamor, J. (2021). Complementor competitive advantage: A framework for strategic decisions. *Journal of Business Research*, *122*, 335–343.

Cennamo, C., & Santalo, J. (2013). Platform competition: Strategic trade-offs in platform markets. *Strategic Management Journal*, *34*(11), 1331–1350.

Cennamo, C., & Santalo, J. (2019). Generativity Tension and Value Creation in Platform Ecosystems. *Organization Science*, *30*(3), 617–641.

Chen, L., Yi, J., Li, S., & Tong, T. W. (2022). Platform Governance Design in Platform Ecosystems: Implications for Complementors' Multihoming Decision. *Journal of Management*, *48*(3), 630-656.

Chen, W., Zhang, C [Cheng], Zheng, Y., & Cui, L. (2009). The Interpretive Flexibility of an E-Government Project: From an Actor-Network Theory Perspective. In *Forty-Second Hawaii International Conference on System Sciences: Hicss 2009,* Waikoloa, HI, United States of America.

Conboy, K., Fitzgerald, G., & Mathiassen, L. (2012). Qualitative methods research in information systems: motivations, themes, and contributions. *European Journal of Information Systems*, *21*(2), 113–118.

Constantinides, P., Henfridsson, O., & Parker, G. G. (2018). Platforms and Infrastructures in the Digital Age. *Information Systems Research*, *29*(2), 381–400.

Corbin, J. M., & Strauss, A. (1990). Grounded theory research: Procedures, canons, and evaluative criteria. *Qualitative Sociology*, *13*(1), 3–21.

Creswell, J. W., & Creswell, J. D. (2018). *Research design: Qualitative, quantitative, and mixed methods approaches* (Fifth edition, international student ed.). SAGE Publications, Inc.

Crotty, M. (2015). *The foundations of social research: Meaning and perspective in the research process* (Reprint). SAGE.

Cusumano, M. A., Yoffie, D. B., & Gawer, A. (2020). The Future of Platforms. *MIT Sloan Management Review*. https://sloanreview.mit.edu/article/the-future-of-platforms/

Dattée, B., Alexy, O., & Autio, E. (2017). Maneuvering in Poor Visibility: How Firms Play the Ecosystem Game when Uncertainty is High. *Academy of Management Journal*, *61*(2), 466-498.

De Reuver, M., Nederstigt, B., & Janssen, M. (2018). Launch Strategies for Multi-Sided Data Analytics Platforms. In *Twenty-Sixth European Conference on Information Systems: ECIS 2018,* Portsmouth, United Kingdom.

De Reuver, M., Sørensen, C., & Basole, R. C. (2018). The Digital Platform: A Research Agenda. *Journal of Information Technology*, *33*(2), 124–135.

Doherty, N. F., Coombs, C. R., & Loan-Clarke, J. (2006). A re-conceptualization of the interpretive flexibility of information technologies: redressing the balance between the social and the technical. *European Journal of Information Systems*, *15*(6), 569–582.

Eaton, B., Elaluf-Calderwood, S., Sørensen, C., & Yoo, Y. (2015). Distributed tuning of boundary resources: The case of Apple's iOS service system. *MIS Quarterly*, *39*(1), 217–243.

Eckhardt, J. T., Ciuchta, M. P., & Carpenter, M. (2018). Open innovation, information, and entrepreneurship within platform ecosystems. *Strategic Entrepreneurship Journal*, *12*(3), 369–391.

Eisenhardt, K. M. (1989). Building Theories from Case Study Research. *The Academy of Management Review*, *14*(4), 532–550.

Eisenhardt, K. M., & Graebner, M. E. (2007). Theory Building From Cases: Opportunities And Challenges. *Academy of Management Journal*, *50*(1), 25–32.

Engert, M., Chu, Y., Hein, A., & Krcmar, H. (2021). Managing the Interpretive Flexibility of Technology: A Case Study of Celonis and its Partner Ecosystem. In *Forty-Second International Conference on Information Systems: ICIS 2021*, Austin, TX, United States of America.

Engert, M., Evers, J., Hein, A., & Krcmar, H. (2022). The Engagement of Complementors and the Role of Platform Boundary Resources in e-Commerce Platform Ecosystems. *Information Systems Frontiers.* Advance online publication.

Engert, M., Fuchs, J., Hein, A., & Krcmar, H. (2021). Enabling Partner Management in Enterprise Platform Ecosystems -A Design Science Research Study. In *Twenty-fifth Pacific Asia Conference on Information Systems: PACIS 2021*, Dubai, UAE.

Engert, M., Hein, A., & Krcmar, H. (2020). Partner Programs and Complementor Assessment in Platform Ecosystems: A Multiple-Case Study. In *Twenty-Sixth Americas Conference on Information Systems: AMCIS 2020*, A Virtual Conference (Due to global COVID-19 situation).

Engert, M., Pfaff, M., & Krcmar, H. (2019). Adoption of Software Platforms: Reviewing Influencing Factors and Outlining Future Research. In *Twenty-Third Pacific Asia Conference on Information Systems: PACIS 2019*, Xi'An, China.

Evans, D. S., & Schmalensee, R. (2010). Failure to Launch: Critical Mass in Platform Businesses. *Review of Network Economics*, *9*(4), Article 1.

Faraj, S., Krogh, G. von, Monteiro, E., & Lakhani, K. R. (2016). Online community as space for knowledge flows. *Information Systems Research*, *27*(4), 668–684.

Farrell, J., & Saloner, G. (1986). Installed Base and Compatibility: Innovation, Product Preannouncements, and Predation. *The American Economic Review*, *76*(5), 940–955.

Floetgen, R. J., Novotny, M., Urmetzer, F., & Böhm, M. (2021). Connecting the Dots of Digital Platform Ecosystem Research: Constructs, Causal Links and Future Research22. In *Twenty-Ninth European Conference on Information Systems 2021: ECIS 2021*, A Virtual AIS Conference (Due to Covid-19).

Foerderer, J. (2017). Relational third-party governance: Evidence from Apple's World Wide Developer Conference. In *Platform Strategy Research Symposium 2017*, Boston, MA, United States of America.

Foerderer, J. (2020). Interfirm Exchange and Innovation in Platform Ecosystems: Evidence from Apple’s Worldwide Developers Conference. *Management Science*, *66*(10), 4772–4787.

Foerderer, J., Kude, T., Mithas, S., & Heinzl, A. (2018). Does Platform Owner’s Entry Crowd Out Innovation? Evidence from Google Photos. *Information Systems Research*, *29*(2), 444–460.

Foerderer, J., Kude, T., Schuetz, S. W., & Heinzl, A. (2019). Knowledge boundaries in enterprise software platform development: Antecedents and consequences for platform governance. *Information Systems Journal*, *29*(1), 119–144.

Foerderer, J., Lueker, N., & Heinzl, A. (2021). And the Winner Is …? The Desirable and Undesirable Effects of Platform Awards. *Information Systems Research*, *32*(4), 1155–1172.

Fotrousi, F., Fricker, S. A., Fiedler, M., & Le-Gall, F. (2014). Kpis for Software Ecosystems: A Systematic Mapping Study. In C. Lassenius & K. Smolander (Chairs), *ICSOB 2014*, Paphos, Cyprus.

Galbraith, J. R. (1974). Organization Design: An Information Processing View. *Interfaces*, *4*(3), 28–36.

Gawer, A. (2014). Bridging differing perspectives on technological platforms: Toward an integrative framework. *Research Policy*, *43*(7), 1239–1249.

Germonprez, M., Hovorka, D., & Collopy, F. (2007). A Theory of Tailorable Technology Design. *Journal of the Association for Information Systems*, *8*(6), 351–367.

Ghazawneh, A., & Henfridsson, O. (2013). Balancing platform control and external contribution in third-party development: The boundary resources model. *Information Systems Journal*, *23*(2), 173–192.

Gioia, D. A., Corley, K. G., & Hamilton, A. L. (2013). Seeking Qualitative Rigor in Inductive Research. *Organizational Research Methods*, *16*(1), 15–31.

Goldbach, T., Benlian, A., & Buxmann, P. (2018). Differential effects of formal and self-control in mobile platform ecosystems: Multi-method findings on third-party developers' continuance intentions and application quality. *Information & Management*, *55*(3), 271–284.

Graça, P., & Camarinha-Matos, L. M. (2017). Performance indicators for collaborative business ecosystems — Literature review and trends. *Technological Forecasting and Social Change*, *116*, 237–255.

Gregor, S., & Hevner, A. R. (2013). Positioning and Presenting Design Science Research for Maximum Impact. *MIS Quarterly*, *37*(2), 337–355.

Hagiu, A., & Wright, J. (2015). Multi-sided platforms. *International Journal of Industrial Organization*, *43*, 162–174.

Halckenhaeusser, A., Foerderer, J., & Heinzl, A. (2020a). Platform Governance Mechanisms: An Integrated Literature Review and Research Directions. In *Twenty-Eighth European Conference on Information Systems: ECIS 2020*, A Digital Conference (due to Covid-19).

Halckenhaeusser, A., Foerderer, J., & Heinzl, A. (2020b). Wolf in a Sheep's Clothing: When Do Complementors Face Competition With Platform Owners? In *Forty-First International Conference on Information Systems: ICIS 2020*, A digital conference (due to Covid-19).

Hein, A., Schreieck, M., Riasanow, T., Setzke, D. S., Wiesche, M., Böhm, M., & Krcmar, H. (2019). Digital platform ecosystems. *Electronic Markets*, *30*(1), 87–98.

Hein, A., Schreieck, M., Wiesche, M., Böhm, M., & Krcmar, H. (2019). The emergence of native multi-sided platforms and their influence on incumbents. *Electronic Markets*, *29*(4), 631–647.

Hein, A., Weking, J., Schreieck, M., Wiesche, M., Böhm, M., & Krcmar, H. (2019). Value co-creation practices in business-to-business platform ecosystems. *Electronic Markets*, *29*(3), 503–518.

Helfat, C. E., & Raubitschek, R. S. (2018). Dynamic and integrative capabilities for profiting from innovation in digital platform-based ecosystems. *Research Policy*, *47*(8), 1391–1399.

Hevner, A. R., & Malgonde, O. (2019). Effectual application development on digital platforms. *Electronic Markets*, *29*(3), 407–421.

Hevner, A. R., March, S. T., Park, J., Ram, S., Hevner, March, Park, & Ram (2004). Design Science in Information Systems Research. *MIS Quarterly*, *28*(1), 75–105.

Hinz, O., Otter, T., & Skiera, B. (2020). Estimating Network Effects in Two-Sided Markets. *Journal of Management Information Systems*, *37*(1), 12–38.

Huang, P., Tafti, A., & Mithas, S. (2018). Platform sponsor investments and user contributions in knowledge communities: The role of knowledge seeding. *MIS Quarterly*, *42*(1), 213–240.

Huber, T. L., Kude, T., & Dibbern, J. (2017). Governance practices in platform ecosystems: Navigating tensions between cocreated value and governance costs. *Information Systems Research*, *28*(3), 563–584.

Hurni, T., Huber, T. L., Dibbern, J., & Krancher, O. (2021). Complementor dedication in platform ecosystems: rule adequacy and the moderating role of flexible and benevolent practices. *European Journal of Information Systems*, *30*(3), 237–260.

Hyrynsalmi, S., & Mäntymäki, M. (2018). Is Ecosystem Health a Useful Metaphor? Towards a Research Agenda for Ecosystem Health Research. In S. A. Al-Sharhan, A. C. Simintiras, Y. K. Dwivedi, M. Janssen, M. Mäntymäki, L. Tahat, I. Moughrabi, T. M. Ali, & N. P. Rana (Eds.), *Lecture Notes in Computer Science: Vol. 11195. Challenges and Opportunities in the Digital Era - IFIP I3E 2018* (pp. 141–149). Springer.

Iansiti, M., & Levien, R. (2002). Keystones and Dominators: Framing the Operational Dynamics of Business Ecosystems. *Harvard Business School Working Paper*(03-061).

Ilivari, J., & Venable, J. R. (2009). Action research and design science research - Seemingly similar but decisively dissimilar. In *Seventeenth European Conference on Information Systems: ECIS 2009*, Verona, Italy.

Jacobides, M. G., Cennamo, C., & Gawer, A. (2018). Towards a theory of ecosystems. *Strategic Management Journal*, *39*(8), 2255–2276.

Jansen, S. (2014). Measuring the health of open source software ecosystems: Beyond the scope of project health. *Information and Software Technology*, *56*(11), 1508–1519.

Jha, A. K., Lee, S., & Lee, W. J. (2019). An empirical study of configuration changes and adoption in Android apps. *Journal of Systems and Software*, *156*, 164–180.

Karhu, K., Gustafsson, R., & Lyytinen, K. (2018). Exploiting and Defending Open Digital Platforms with Boundary Resources: Android's Five Platform Forks. *Information Systems Research*, *29*(2), 479–497.

Koch, S., & Guceri-Ucar, G. (2017). Motivations of application developers: Innovation, business model choice, release policy, and success. *Journal of Organizational Computing and Electronic Commerce*, *27*(3), 218–238.

Kohli, R., & Grover, V. (2008). Business Value of IT: An Essay on Expanding Research Directions to Keep up with the Times. *Journal of the Association for Information Systems*, *9*(1), 23–39.

Kulkarni, U. R., Robles-Flores, J. A., & Popovič, A. (2017). Business intelligence capability: The effect of top management and the mediating roles of user participation and analytical decision making orientation. *Journal of the Association for Information Systems*, *18*(7), 516–541.

Kummer, M., & Schulte, P. (2019). When private information settles the bill: Money and privacy in Google's market for smartphone applications. *Management Science*, *65*(8), 3470–3494.

Leidner, D. E. (2018). Review and Theory Symbiosis: An Introspective Retrospective. *AIS Transactions on Human-Computer Interactions (THCI) AIS Transactions on Replication Research*, *19*(06), 552–567.

Leong, C., Pan, S. L., Leidner, D. E., & Huang, J.-S. (2019). Platform Leadership: Managing Boundaries for the Network Growth of Digital Platforms. *AIS Transactions on*

Human-Computer Interactions (THCI) AIS Transactions on Replication Research, 1531–1565.

Levers, M.-J. D. (2013). Philosophical Paradigms, Grounded Theory, and Perspectives on Emergence. *SAGE Open*, *3*(4), 1-6.

Li, H., & Kettinger, W. J. (2021). The Building Blocks of Software Platforms: Understanding the Past to Forge the Future. *AIS Transactions on Human-Computer Interactions (THCI) AIS Transactions on Replication Research*, *22*(6), 1524–1555.

Li, H., Zhang, C [Chen], & Kettinger, W. J. (2022). Digital Platform Ecosystem Dynamics: The Roles of Product Scope, Innovation, and Collaborative Network Centrality. *MIS Quarterly*, *forthcoming*.

Li, J., Chen, L., Yi, J., Mao, J., & Liao, J. (2019). Ecosystem-specific advantages in international digital commerce. *Journal of International Business Studies*, *50*(9), 1448–1463.

Lusch, R. F., & Nambisan, S. (2015). Service Innovation: A Service-Dominant Logic Perspective. *MIS Quarterly*, *39*(1), 155–175.

McIntyre, D. P., & Srinivasan, A. (2017). Networks, platforms, and strategy: Emerging views and next steps. *Strategic Management Journal*, *38*(1), 141–160.

McIntyre, D. P., Srinivasan, A., Afuah, A., Gawer, A., & Kretschmer, T. (2020). Multi-sided platforms as new organizational forms. *Academy of Management Perspectives*, *35*(4), 566–583.

McIntyre, D. P., Srinivasan, A., & Chintakananda, A. (2021). The persistence of platforms: The role of network, platform, and complementor attributes. *Long Range Planning*, *54*(5), 101987.

Miric, M., Boudreau, K. J., & Jeppesen, L. B. (2019). Protecting their digital assets: The use of formal & informal appropriability strategies by App developers. *Research Policy*, *48*(8), 103738.

Nambisan, S., Siegel, D., & Kenney, M. (2018). On open innovation, platforms, and entrepreneurship. *Strategic Entrepreneurship Journal*, *12*(3), 354–368.

Nambisan, S., Zahra, S. A., & Luo, Y. (2019). Global platforms and ecosystems: Implications for international business theories. *Journal of International Business Studies*, *50*(9), 1464–1486.

O'Mahony, S., & Karp, R. (2022). From proprietary to collective governance: How do platform participation strategies evolve? *Strategic Management Journal*, *43*(3), 530–562.

Orlikowski, W. J., & Baroudi, J. J. (1991). Studying Information Technology in Organizations: Research Approaches and Assumptions. *Information Systems Research*, *2*(1), 1–28.

Österle, H., Becker, J., Frank, U., Hess, T., Karagiannis, D., Krcmar, H., Loos, P., Mertens, P., Oberweis, A., & Sinz, E. J. (2011). Memorandum on design-oriented information systems research. *European Journal of Information Systems*, *20*(1), 7–10.

Ozalp, H., Cennamo, C., & Gawer, A. (2018). Disruption in Platform-Based Ecosystems. *Journal of Management Studies*, *55*(7), 1203–1241.

Panico, C., & Cennamo, C. (2022). User Preferences And Strategic Interactions In Platform Ecosystems. *Strategic Management Journal*, *43*(3), 507–529.

Paré, G., & Elam, J. J. (1997). Using Case Study Research to Build Theories of IT Implementation. In A. S. Lee, J. Liebenau, & J. I. DeGross (Eds.), *IFIP - The International Federation for Information Processing. Information Systems and*

Qualitative Research: Proceedings of the IFIP TC8 WG 8.2 International Conference on Information Systems and Qualitative Research, 31st May-3rd June 1997, Philadelphia, Pennsylvania, USA (Vol. 35, pp. 542–568). Springer.

Parker, G. G., van Alstyne, M. W., & Jiang, X. (2017). Platform ecosystems: How developers invert the firm. *MIS Quarterly*, *41*(1), 255–266.

Peffers, K., Tuunanen, T., Rothenberger, M. A., & Chatterjee, S. (2007). A Design Science Research Methodology for Information Systems Research. *Journal of Management Information Systems*, *24*(3), 45–77.

Perrons, R. K. (2009). The open kimono: How Intel balances trust and power to maintain platform leadership. *Research Policy*, *38*(8), 1300–1312.

Plakidas, K., Schall, D., & Zdun, U. (2017). Evolution of the R software ecosystem: Metrics, relationships, and their impact on qualities. *Journal of Systems and Software*, *132*, 119–146.

Premukmar, R. G., Ramamurthy, K., & Saunders, C. (2005). Information Processing View of Organizations: An Exploratory Examination of Fit in the Context of Interorganizational Relationships. *Journal of Management Information Systems*, *22*(1), 257–294.

Rietveld, J., & Eggers, J. P. (2018). Demand heterogeneity in platform markets: Implications for complementors. *Organization Science*, *29*(2), 304–322.

Saadatmand, F., Lindgren, R., & Schultze, U. (2019). Configurations of platform organizations: Implications for complementor engagement. *Research Policy*, *48*(8), 103770.

Salesforce. (2021). *FY21 Annual Report: Success From Anywhere.* Salesforce.com. https://s23.q4cdn.com/574569502/files/doc_financials/2021/ar/Salesforce-FY-2021-Annual-Report.pdf

Sarker, S [Suprateek], Sarker, S [Saonee], Sahaym, A., & Bjørn-Andersen, N. (2012). Exploring Value Cocreation in Relationships Between an ERP Vendor and its Partners: A Revelatory Case Study. *MIS Quarterly*, *36*(1), 317–338.

Schaffer, N., Engert, M., Leontjevs, G., & Krcmar, H. (2020). A Tool to Model and Simulate Dynamic Business Models. In *Thirty-Third Bled eConference – Enabling Technology for a Sustainable Society: Bled 2020,* Online Conference due to COVID-19.

Schaffer, N., Ritzenhoff, M., Engert, M., & Krcmar, H. (2021). From Specialization to Platformization: Business Model Evolution in the Case of ServiceNow. In *Twenty-Ninth European Conference on Information Systems 2021: ECIS 2021,* A Virtual AIS Conference (Due to Covid-19).

Schreieck, M., Wiesche, M., & Krcmar, H. (2016). Design and Governance of Platform Ecosystems – Key Concepts and Issues for Future Research. In *Twenty-Fourth European Conference on Information Systems: ECIS 2016,* Istanbul, Turkey.

Schreieck, M., Wiesche, M., & Krcmar, H. (2017). The Platform Owner's Challenge to Capture Value – Insights from a Business-to-Business IT Platform. In *Thirty-Eighth International Conference on Information Systems: ICIS 2017,* Seoul, South Korea.

Schreieck, M., Wiesche, M., & Krcmar, H. (2018). Multi-Layer Governance in Platform Ecosystems of Established Companies. In *Academy of Management Proceedings,* Chicago, IL, United States of America.

Schreieck, M., Wiesche, M., & Krcmar, H. (2021). Capabilities for Value Co-Creation and Value Capture in Emergent Platform Ecosystems: A Longitudinal Case Study of SAP’s Cloud Platform. *Journal of Information Technology*, *36*(4), 365-390.

Schreieck, M., Wiesche, M., Kude, T., & Krcmar, H. (2019). Shifting to the Cloud – How SAP's Partners Cope with the Change. In *Fifty-Second Hawaii International Conference in Systems Sciences: HICSS 2019*, Maui, HI, United States of America.

Schryen, G., Wagner, G., Benlian, A., & Paré, G. (2021). A Knowledge Development Perspective on Literature Reviews: Validation of a new Typology in the IS Field. *Communications of the Association of Information Systems*, *49*(1), 134–186.

Shilton, K., & Greene, D. (2019). Linking Platforms, Practices, and Developer Ethics: Levers for Privacy Discourse in Mobile Application Development. *Journal of Business Ethics*, *155*(1), 131–146.

Song, J., Baker, J., Wang, Y., Choi, H. Y., & Bhattacherjee, A. (2018). Platform adoption by mobile application developers: A multimethodological approach. *Decision Support Systems*, *107*, 26–39.

Song, P., Xue, L., Rai, A., & Zhang, C [Cheng] (2018). The ecosystem of software platform: A study of asymmetric cross-side network effects and platform governance. *MIS Quarterly*, *42*(1), 121–142.

Stummer, C., Kundisch, D., & Decker, R. (2018). Platform Launch Strategies. *Business & Information Systems Engineering*, *60*(2), 167–173.

Tan, B., Pan, S. L., Lu, X., & Huang, L. (2015). The Role of IS Capabilities in the Development of Multi-Sided Platforms: The Digital Ecosystem Strategy of Alibaba.com. *Journal of the Association for Information Systems*, *16*(4), 248–280.

Tavalaei, M. M., & Cennamo, C. (2021). In search of complementarities within and across platform ecosystems: Complementors' relative standing and performance in mobile apps ecosystems. *Long Range Planning*, *54*(5), 101994.

Teece, D. J. (2017). Dynamic Capabilities and (Digital) Platform Lifecycles. In J. L. Furman, A. Gawer, B. S. Silverman, & S. Stern (Eds.), *Advances in Strategic Management: Volume 37. Entrepreneurship, Innovation, and Platforms* (pp. 211–225). Emerald Publishing.

Teece, D. J. (2018). Profiting from innovation in the digital economy: Enabling technologies, standards, and licensing models in the wireless world. *Research Policy*, *47*(8), 1367–1387.

Tilson, D., Lyytinen, K., & Sørensen, C. (2010). Digital infrastructures: The missing IS research agenda. *Information Systems Research*, *21*(4), 748–759.

Tiwana, A. (2014). *Platform ecosystems: Aligning architecture, governance, and strategy*. Morgan Kaufmann.

Tiwana, A. (2015). Evolutionary Competition in Platform Ecosystems. *Information Systems Research*, *26*(2), 266–281.

Tiwana, A., Konsynski, B., & Bush, A. A. (2010). Platform evolution: Coevolution of platform architecture, governance, and environmental dynamics. *Information Systems Research*, *21*(4), 675–687.

Tiwana, A., Konsynski, B., & Venkatramen, N. (2013). Information Technology and Organizational Governance: The IT Governance Cube. *Journal of Management Information Systems*, *30*(3), 7–12.

Uotila, J., Keil, T., & Maula, M. (2017). Supply-side network effects and the development of information technology standards. *MIS Quarterly*, *41*(4), 1207–1226.

Valença, G., & Alves, C. (2017). A theory of power in emerging software ecosystems formed by small-to-medium enterprises. *Journal of Systems and Software*, *134*, 76–104.

van Angeren, J., Alves, C., & Jansen, S. (2016). Can We Ask You To Collaborate? Analyzing App Developer Relationships in Commercial Platform Ecosystems. *Journal of Systems and Software*, *113*, 430–445.

Venable, J., Pries-Heje, J., & Baskerville, R. L. (2016). FEDS: a Framework for Evaluation in Design Science Research. *European Journal of Information Systems*, *25*(1), 77–89.

Verhoef, P. C., Reinartz, W. J., & Krafft, M. (2010). Customer Engagement as a New Perspective in Customer Management. *Journal of Service Research*, *13*(3), 247–252.

Vom Brocke, J., Simons, A., Niehaves, B., Reimer, K., Plattfaut, R., & Cleven, A. (2009). Reconstructing the Giant: On the Importance of Rigour in Documenting the Literature Search Process. In *Seventeenth European Conference on Information Systems: ECIS 2009*, Verona, Italy.

Wamba, S. F., Gunasekaran, A., Akter, S., Ren, S. J., Dubey, R., & Childe, S. J. (2017). Big data analytics and firm performance: Effects of dynamic capabilities. *Journal of Business Research*, *70*, 356–365.

Wan, X., Cenamor, J., Parker, G. G., & van Alstyne, M. W. (2017). Unraveling platform strategies: A review from an organizational ambidexterity perspective. *Sustainability*, *9*(5), 734–752.

Wang, P. (2021). Connecting the Parts with the Whole: Toward an Information Ecology Theory of Digital Innovation Ecosystems. *MIS Quarterly*, *45*(1b), 397–422.

Wang, R. D., & Miller, C. D. (2019). Complementors' engagement in an ecosystem: A study of publishers' e-book offerings on Amazon Kindle. *Strategic Management Journal*, *76*(3), 3–26.

Wareham, J., Fox, P. B., & Giner, J. (2014). Technology ecosystem governance. *Organization Science*, *25*(4), 1195–1215.

Webster, J., & Watson, R. T. (2002). Analyzing the Past to Prepare for the Future: Writing a Literature Review. *MIS Quarterly*, *26*(2), xiii–xxiii.

Wiesche, M., Jurisch, M. C., Yetton, P. W., & Krcmar, H. (2017). Grounded Theory Methodology in Information Systems Research. *MIS Quarterly*, *41*(3), 685–701.

Williamson, P. J., & Meyer, A. de (2012). Ecosystem Advantage: How to Successfully Harness the Power of Partners. *California Management Review*, *55*(1), 24–46.

Xue, L., Song, P., Rai, A., Zhang, C [Cheng], & Zhao, X. (2019). Implications of Application Programming Interfaces for Third-Party New App Development and Copycatting. *Production and Operations Management*, *28*(8), 1887–1902.

Yin, R. K. (2018). *Case study research and applications: Design and methods* (Sixth edition). SAGE.

Zittrain, J. (2006). The Generative Internet. *Harvard Law Review*, *119*, 1974–2040.

Appendix: Embedded Publications in Original Format

Appendix A. (P1) Adoption of Software Platforms: Reviewing Influencing Factors and Outlining Future Research

Adoption of Software Platforms: Reviewing Influencing Factors and Outlining Future Research

Completed Research Paper

Martin Engert
fortiss GmbH
Munich, Germany
engert@fortiss.org

Matthias Pfaff
fortiss GmbH
Munich, Germany
pfaff@fortiss.org

Helmut Krcmar
Technical University Munich
Munich, Germany
krcmar@in.tum.de

Abstract

Software platforms have received attention as the dominant model for cooperative software development. Growing the ecosystems around software platforms through increasing adoption by users and developers is of great importance for platform owners. However, there is a lack of research on how to increase adoption and growth of software platforms systematically. To address this issue, we conduct a literature review and make an in-depth analysis to uncover and organize factors that drive adoption of software platforms. Additionally, we derive effective directions of these factors on the respective sides. Finally, we outline three avenues for future research: aligning research on platform governance and platform launch and growth, taking an evolutionary, growth-oriented perspective on governance of software platforms and further detailing platform launch and growth strategies towards a design theory for platform launch. This paper contributes to the understanding of software platforms by reviewing factors driving adoption and triggering network effects.

Keywords: Software Platform Ecosystem, Launch strategy, Growth strategy, Platform adoption, Network effects

Introduction

Software platforms have established themselves as the dominant model for cooperative software development and software-based services (Reuver et al. 2018b; Tiwana et al. 2010). Typical domains for platform-centric software ecosystems are web browsers like Firefox or Google Chrome and mobile operating systems like iOS and Android. Following Tiwana et al. (2010, p. 675), we define software platforms as the "[..] extensible codebase of a software-based system that provides core functionality shared by the modules that interoperate with it and interfaces through which they interoperate [..].". As highlighted by the examples, software platforms rely on developers in order to create valuable experiences for users with the platform mediating transactions between the groups, operating as two-sided platforms (Anderson et al. 2014; Cennamo and Santalo 2013). Creating and maintaining the ecosystem around a platform is a huge challenge for its operator. Since platforms are usually characterized as two-sided or multi-sided markets, they need to attract and cater at least two platform sides. The *user-side* (i.e. consumer-side) and *complementor-side* (i.e. developer-side or app-side) (Evans 2009). The interaction of both sides via the platform creates direct and indirect network effects (Eisenmann 2008; Katz and Shapiro 1994). An initial chicken-egg problem occurs within the ecosystem, since users will choose platforms that, among others, offer a variety of applications and developers will focus, among others, on platforms that offer a large audience of possible users (Caillaud and Jullien 2003; Schirrmacher et al. 2017). Therefore, growing the platform ecosystem on both sides through increasing adoption and thus diffusion of its underlying digital technologies is crucial and depends on a multitude of different factors (Eisenmann 2008; Gawer 2014).

However, despite existing research on the topic, there is a lack of findings on how to increase adoption and growth of software platforms systematically (Tan et al. 2015). Prior research has attempted to mitigate these issues by introducing strategies for platform owners to launch and grow their platforms (Evans 2009; Evans and Schmalensee 2010; Wan et al. 2017). Still, these strategies lack empirical foundation as they are conceptual in nature (Reuver et al. 2018a; Tan et al. 2015). Descriptions of launch strategies are reduced to basic instructions, without references on how to specifically address the platform sides. This situation lead to calls for further investigation of factors and mechanisms that influence adoption and growth of multi-sided platforms by users and developers (Ondrus et al. 2015; Wessel et al. 2017). Therefore, the purpose of this paper is to make an in-depth analysis to uncover and organize factors that influence adoption of software platforms and thus growth of software ecosystems with regard to the two platform sides. Additionally, we show whether literature indicates any effective directions - direct or indirect, of these factors on the respective sides. The contribution aims to further enable platform owners to purposefully increase adoption of their platforms. To this end, we conduct a systematic literature review to identify relevant factors associated with adoption of software platforms. We further evaluate the factors regarding their direct and indirect influence on the two platforms sides based on insights of prior work. Hence, we are able to contribute to the discussion on platform launch and growth through providing factors driving adoption and their effective direction.

The remainder of this paper is structured as the following. We first present a literature review and the methodology of this study. Second, we introduce and group the factors driving adoption of software platforms identified from prior work. Third, we propose issues for future research that emerge from our findings. Last, we briefly discuss our results.

Critical Mass, Network Effects and Diffusion

For platforms to succeed, prior contributions have highlighted the importance of reaching critical mass. Critical mass refers to a sufficient number of users and/or complementors on the platform to spark growth and overcome the chicken-egg problem (Caillaud and Jullien 2003; Cennamo and Santalo 2013; Evans 2009). Amit and Zott (2001) note, that not the sheer number of participants in an ecosystem, but the number of transactions or liquidity of the platform is decisive. Still, the number of participants on all platform sides is a proxy for these alternative measures.

Reaching critical mass in platform settings strongly depends on the value created by network effects (Evans and Schmalensee 2010; Katz and Shapiro 1986). The value a prospect participant obtains from a platform is based on two parts. First, the direct value derived from the platform itself and second, the value she may derive from the presence of and the interaction with peer-group and cross-group participants. Network effects describe the second part, the increased value a platform participant derives from the participation of others (Farrell and Saloner 1985; Katz and Shapiro 1986). Direct network effects arise when value for one user strongly depends on the presence, characteristics and/or actions of users of the same group such as in telephone networks or social networks (McIntyre and Srinivasan 2017). Since users' interest in software platforms primarily is not in direct interaction with peers, but in complements and vice versa, so-called indirect or cross-side network effects emerge (Song et al. 2018). Indirect network-effects are key to adoption and growth of digital ecosystems, since they strongly scale the value a prospect participant will derive from joining the platform. This accumulated value and its lock-in effect is the reason platform markets tend to have winner-takes all or at least winner-takes some dynamics, leading to wide diffusion and high level of adoption of certain platforms (Cennamo and Santalo 2013; Gallaugher and Wang 2002).

Prior Work Related to Adoption of Software Platforms by Complementors and Users

As pointed out, direct and indirect network effects impact adoption decisions of both users and developers in software platforms. Nevertheless, the details on the factors driving network effects and what manifests their strength are yet to be explored (McIntyre and Srinivasan 2017).

Prior contributions have analyzed various factors driving adoption, usually in isolation or with restriction to certain sets of aspects. For instance, pricing in multi-sided platforms has been examined by a multitude of authors. The general assumption within this research stream is that establishing the right pricing structure is the key to leverage network effects and thus spark ecosystem growth (Bakos and Katsamakas 2008; Rochet and Tirole 2006; Rysman 2009). Still, finding the right pricing structure is a difficult task for platform owners, since direction and intensity of network effects remain unknown. Another factor that has received considerable attention is platform openness and its influence on platform adoption (Soto Setzke et al. 2019). Benlian et al. (2015) develop a concept to evaluate platform openness, which they view as one of the primary drivers for platform growth. Other important factors that have been studied are governance, design and architecture of digital platforms (Kazan et al. 2018; Manner et al. 2013; Schreieck et al. 2016) and the relationship of platform owner and ecosystem participants such as application developers (Hein et al. 2018). One concept that is used to describe a subset of factors that can drive adoption of software platforms by developers are platform boundary resources. It subsumes software tools and regulations that are used to govern the relationship between platform owner and developer (Ghazawneh and Henfridsson 2013). While being studied in prior works, these factors have mostly been examined in isolation and without special focus on platform adoption. Further, the effective direction of these factors has often not been indicated.

Methodology of the Literature Review

The primary goal of this literature review is to identify publications that (a) focus on software platform ecosystems as the main topic of analysis, (b) derive explicit or implicit insights into factors influencing platform adoption via network effects and (c) do not solely take the user perspective. The design for the systematic literature review is adapted from the guidelines proposed by Webster and Watson (2002) and Vom Brocke et al. (2009). To ensure validity of our search we focused on literature from two research fields when choosing the relevant top journals (Vom Brocke et al. 2009). The restriction of our review to the fields of information systems (IS) and strategy and management literature is justified by the fuzziness of the term network effects, which is often referenced in these research areas. Since our overarching research focuses on growing software platform ecosystems from a platform owner perspective, we decided to focus on the AIS Senior Scholars' Basket of Journals and top strategy and management journals. As the database, we utilized SCOPUS, which yielded 239 hits using the keywords: (platform OR ecosystem OR *sided market) AND (software OR application OR complement*) AND (network AND (effect* OR externalit*)). To ensure inclusion of up-to-date research, we added the top IS conferences according to the Association for Information Systems, which we searched in the Association for Information Systems electronic library. In a two-staged selection process, we scanned and sorted the articles from the databases based on title and abstract. After a full-text review of the remaining articles, we selected 55 articles as relevant to our research endeavor. A forward and backward search resulted in another 14 selected articles.

Results of the Literature Review

In this part, we will summarize the insights we gained during the review. When analyzing the articles, we coded relevant factors that drive adoption of software platforms. For an even deeper understanding, platform owners need to know what factors affect which platforms sides through direct and/or indirect effects. Prior work on platform launch strategies, which deals with the coordination problem in two-sided platforms face in their pre-ignition stage, suggests that both platform sides have to be addressed via differing factors and mechanisms (Schirrmacher et al. 2017). As confirmed by the findings of Song et al. (2018), certain factors affect the user and developer-side of a platform in different ways. Platform owners can incorporate this knowledge into platform launch and growth strategies and the underlying configuration of design and governance of their platforms. For this reason, we also coded the direction of the effects the identified factors are likely to trigger. During the coding process, we were able to identify three categories for the factors, which are based on the three sources of network externalities identified by Katz and Shapiro (1985). We will outline these categories before further presenting the factors driving adoption in the following.

Figure 1 shows the three categories the factors driving software platform adoption were assigned to. The categories are *universal*, *semi-universal* and *specific*, relating to whether a factor may be used to address both platform sides directly and indirectly, both platform sides partly or only one side directly.

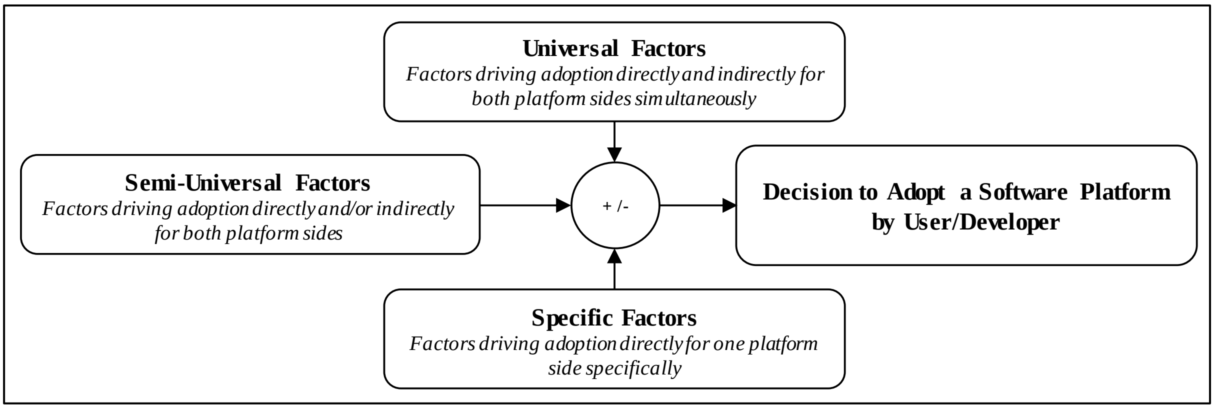

Figure 1 Categories of Factors Driving Adoption of Software Platforms

It is important to note, that the factors can have positive or negative impact on the adoption decision of users or developers of software platforms. Table 1 shows the factors we coded from prior works, their respective category and the effective direction these factors have. The categories and selected factors will be outlined in the next section.

Table 1 Factors Driving Software Platform Adoption

Factors Driving Adoption		Direction of Effects				Sources (indicating the direction of the effects)
		Complementor		User		
		Direct	Indirect	Direct	Indirect	
Universal	Platform Pricing Structure	x	x	x	x	(Armstrong 2006; Casadesus-Masanell and Hałaburda 2014; Clements and Ohashi 2004; Conte et al. 2010; Ghose and Han 2014; Koh and Fichman 2014; Mantena and Saha 2012; Parker and van Alstyne 2005; Tanriverdi and Chi-Hyon 2008; Yoo et al. 2002)
	Platform Strategy	x	x	x	x	(Eisenmann et al. 2011; Ghose and Han 2014; Huang et al. 2013; Li and Agarwal 2017; McIntyre and Subramaniam 2009; Tanriverdi and Chi-Hyon 2008)
	Governance & Control	x	x	x	x	(Boudreau 2010; Ghazawneh and Henfridsson 2015; Song et al. 2018; Tiwana et al. 2010)

	Platform Technological Performance	x	x	x	x	(Anderson et al. 2014; Bakos and Katsamakas 2008; Hann et al. 2016)
	Platform Updates	x	x	x	x	(Hann et al. 2016; Song et al. 2018)
Semi-Universal	**In-House development by Platform**	x	x	x		(Eisenmann et al. 2009; Huang et al. 2009; Li and Agarwal 2017; West 2003)
	App Updates	x	x	x		(Claussen et al. 2013; Tiwana 2015)
	Exclusivity of Apps	x	x	x		(Cennamo and Santalo 2013; Kang and Lee 2013; Parker et al. 2017; Srinivasan and Venkatraman 2008)
	Installed Base of Users	x	x	x		(Anderson et al. 2014; Boudreau 2010; Cennamo and Santalo 2013; Eisenmann et al. 2011)
	Quality of Apps	x		x	x	(Claussen et al. 2013; Ghose and Han 2014; Markovich and Moenius 2009; Song et al. 2018; Tanriverdi and Chi-Hyon 2008; Wareham et al. 2014; Zhu and Iansiti 2012)
	Platform Transparency	x		x		(Bhargava and Choudhary 2004; Gawer 2014)
	Power Relation	x		x		(Boudreau 2010)
	Killer Apps		x	x		(Anderson et al. 2014; Claussen et al. 2013; Srinivasan and Venkatraman 2008)
	Ecosystem Growth Potential		x	x		(Li et al. 2014; McIntyre and Srinivasan 2017)
	Word of Mouth		x	x		(Li and Agarwal 2017; McIntyre and Srinivasan 2017)
	Appropriability Regime	x	x		x	(Boudreau 2010; Ceccagnoli et al. 2012; West 2003)
	App Reviews by Platform	x	x		x	(Claussen et al. 2013; Li et al. 2014; Song et al. 2018; Wessel et al. 2017)
	Platform Architecture & Design	x	x		x	(Bakos and Katsamakas 2008; McIntyre and Srinivasan 2017; Song et al. 2018)
	Developer Properties	x			x	(Boudreau and Jeppesen 2015; Ghose and Han 2014; Hilkert et al. 2010; Kankanhalli et al. 2015; Markovich and Moenius 2009; Song et al. 2018; Tanriverdi and Chi-Hyon 2008; Venkatraman and Lee 2004; Yoo 2005)
	Intraplatform Competition	x			x	(Boudreau 2012; Boudreau and Jeppesen 2015; Cennamo and Santalo 2013; Claussen et al. 2013; Huotari 2017; Li et al. 2014; Venkatraman and Lee 2004; Wareham et al. 2014; Wessel et al. 2017)
	Knowledge Sharing	x			x	(Ghose and Han 2014; Perrons 2009)
	Compatibility & Standards		x		x	(Ceccagnoli et al. 2012; Corts and Lederman 2009; Gallaugher and Wang 2002; Huang et al. 2013)
	Quantity of Apps		x		x	(Belleflamme and Toulemonde 2009; Boudreau 2012; Cennamo and Santalo 2013; McIntyre and Srinivasan 2017; Oh et al. 2015; Ondrus et al. 2015; Parker and van Alstyne 2005; Seamans and Zhu 2014; Tan et al. 2015; Tanriverdi and Chi-Hyon 2008; Yoo et al. 2002; Zhu and Iansiti 2012)
	Store App Description	x	x			(Ghose and Han 2014; Wessel et al. 2017)
Specific	**Factors directly driving adoption for complementors only:** Platform Lifecycle Stage, SDK for Developers, Information Policy by Platform, Service Versioning by Platform, Ease of Multi-Homing for Developers, Accessibility for Developers, Platform-Specific Development Costs, Downstream Capabilities, Piracy of Apps, Trust, Interaction with Platform, Developer Community, Interplatform Competition, Total Market Size, Lead User Influence, Ease of Use, Trialability of Apps **Factors directly driving adoption for users only:** Ease of Multi-Homing for Users, Variety of Apps					

Universal factors drive adoption of software platforms via four different effects: First they have a direct effect on both platform sides, users and complementors. Second, they have indirect influence on both sides respectively. These characteristics make the factors in this group very important for platform owners, since they allow the owner to address both platform sides simultaneously and via different effects. For instance, *Platform Pricing Structure*, which has been intensely studied by researchers has direct influence on the adoption decisions of complementors and users through setting of prices by the platform owner (Parker and van Alstyne 2005). At the same time the price developers have to pay has indirect effects on the adoption decision of users, which might face a subsequent increase or decrease of prices they pay for the complements provided by developers. Analogously, high or low prices for users will indirectly affect the adoption by complementors. This is due to users possibly refusing to adopt a certain platform for high initial prices, leading to decreased overall demand for complements (Yoo et al. 2002). Other factors driving adoption universally are *Platform Strategy, Governance & Control, Platform Technological Performance* and *Platform Updates.*

Semi-universal factors are characterized by being able to influence both platforms sides directly and/or indirectly through two or three different effects. That means, these factors influence the adoption decisions of both platforms sides at the same time, without being fully universal in their directions. The decision regarding *In-House Development by the Platform Owner* has direct and indirect effects on the adoption decision of complementors. Direct effects relate to the additional competition for complementors they face when adopting a certain software platform, while indirect effects come into play, when users are attracted to the platform through initial in-house development by the platform owner (West 2003). At the same time users only face direct effects through the availability of additional software provided by the platform owner (Eisenmann et al. 2009; Li and Agarwal 2017).

Specific factors only influence the adoption decision of one specific platform side. Interestingly, we only found evidence for direct effects in prior contributions regarding specific factors. Examples for developer-specific factors are *Platform Lifecycle Stage* or the *SDK for Developers*. These factors have direct influence on the adoption decision of complementors. For users we identified the *Variety of Apps* and *The Costs for Multi-Homing for Users* as the two only factors driving adoption directly.

Whether the effect of a certain factor on a platform side is positive or negative can vary based on its manifestation and other contingency factors. The influence of contingency factors has been excluded from our analysis and is an issue for future work. The same holds true for the strength of the effects caused by the various factors. However, based on the factors and their respective effective direction we provide platform owners with key insights on software platform ecosystem growth. Further, future research can build on our work and advance the topic in different directions.

Central Issues for Future Research

In this section we discuss the central issues for future research on software platform adoption and the way future research may utilize our findings to support platform owners in launching and growing their platforms. We will discuss three major issues.

Aligning Platform Governance and Platform Launch and Growth

We identified a large set of factors that drive adoption of software platforms by users and developers and their effective directions. Building on that, platform owners have first indications on how to launch and grow their platforms through purposefully triggering adoption of their platform. Still, there is a gap between research of platform governance – one of the main levers for platform owners to shape their ecosystem - and the factors driving adoption presented in this contribution (Manner et al. 2013; Song et al. 2018).

Future research my close this gap by identifying concepts of platform governance from prior research that are able to activate or inhibit the respective factors driving adoption. Mapping the governance concepts onto the factors discussed here will help close the gap on governing platform launch and growth. One starting point is to focus on platform boundary resources, since they constitute an important subset of factors driving adoption (Ghazawneh and Henfridsson 2015).

Towards an Evolutionary Approach to Platform Governance

Launching and growing digital platforms is a highly dynamic process requiring platform owners to make various adjustments to strategy, business model and governance. Prior work on concepts for platform governance have neglected this issue. Wareham et al. (2014) call for an evolutionary perspective for governance, embracing differing maturity levels of ecosystems over time.

An issue for future work therefore is to find configurations of platform governance for differing stages of maturity. Driving adoption is central to the launch and growth stages of digital platforms, which is why the evolution of governance needs to take into account the different factors that drive adoption of platforms in different stages. Connecting insights of governance for the launch and growth of digital platforms with theory on the evolution of platforms yields further opportunities for further research.

Empirical Evidence for a Design Theory of Platform Launch

An issue with prior work on platform launch strategies has been the lack of empirical evidence, leaving platform owners alone with detailing these strategies and configuring factors like business models and governance without guidance (Evans and Schmalensee 2010; Reuver et al. 2018a). Reuver et al. (2018a) call for a design theory for platform launch.

Future research should address this issue with empirical work on platform launch and growth strategies using detailed insights from practice. Of special interests may be platforms that took long journeys along their line of evolution, applying different strategies or elements of strategies. First, this helps with understanding the impacts of these elements. Second, this knowledge can be used to specify strategies and further provide fully actionable strategies for platform owners. One starting point for developing such a design theory can be factors that drive adoption of digital platforms. The use of micro-strategies and microstructures when strategizing in a digital platform context as proposed by Staykova (2018) seems a promising approach. It allows to integrate knowledge of factors driving adoption, platform governance to trigger the factors driving adoption and platform strategy as the overarching guidelines for platform governance. The strategic use of appropriability mechanisms is an example for such a micro-strategy that strongly influences adoption by developers (Boudreau 2010; West 2003).

Conclusion

In this contribution, we identified factors driving adoption of software platforms leading to ecosystem growth. Further, we investigated the respective effects that these factors can trigger. Based on these results we propose three issues for future research. First, we call for future work to close the gap between ecosystem growth and platform governance. Integrating concepts from research on digital platform governance and the factors driving adoption from this research might be able to bridge the gap between platform governance and adoption of digital platforms. It therefore is also a first step towards the targeted use of governance in platform launch and growth strategies. Second, since launch and growth of platforms follows evolutionary steps, governance mechanisms need to be adjusted accordingly and be in tune with the strategy in place. Thus, we join recent calls for an evolutionary perspective on governance on digital platforms. Third, the lack of evidence and best practices regarding the details of launch and growth strategies highlights the need for further empirical investigation. Using micro-strategies and microstructures may be a first step in making launch and growth of digital platforms actionable and building a design theory for platform launch.

By reviewing existing literature in IS, strategy and management we contribute to literature in several ways. We first strengthen the understanding on network effects within software platforms through finding factors that drive adoption of software ecosystems and thus trigger network effects. Second, having knowledge about which factors are able to address the respective platform sides directly or indirectly, advances conceptualization and implementation of platform launch and growth strategies. This contribution therefore makes an important step towards the utilization of network effects in platform strategy. Third, linking our results with prior research yields three avenues to advance theoretical discussion on launch and growth of digital platform ecosystem.

Naturally, this contribution underlies several limitations. First, searching and reviewing literature has limitations regarding the outlets and keywords chosen to identify relevant articles. Further, we decided not to focus on the user perspective solely. Extending the list of outlets to domains of marketing and economics and using more and broader keywords will likely help corroborating the initial results. Second, the coding process of the factors driving adoption is subjective. Focusing on different factors in detail will be able to mitigate inaccuracies originating from consolidation of different sources.

References

Amit, R. H., and Zott, C. 2001. "Value Creation in E-Business," *Strategic Management Journal* (22:6-7), pp. 493–520.

Anderson, E. G., Parker, G. G., and Tan, B. 2014. "Platform performance investment in the presence of network externalities," *Information Systems Research* (25:1), pp. 152–172.

Armstrong, M. 2006. "Competition in two-sided markets," *The RAND Journal of Economics* (37:3), pp. 668–691.

Bakos, Y., and Katsamakas, E. 2008. "Design and ownership of two-sided networks: Implications for internet platforms," *Journal of Management Information Systems* (25:2), pp. 171–202.

Belleflamme, P., and Toulemonde, E. 2009. "Negative Intra-Group Externalities in Two-Sided Markets," *International Economic Review* (50:1), pp. 245–272.

Benlian, A., Hilkert, D., and Hess, T. 2015. "How open is this platform? The meaning and measurement of platform openness from the complementors' perspective," *Journal of Information Technology* (30:3), pp. 209–228.

Bhargava, H. K., and Choudhary, V. 2004. "Economics of an information intermediary with aggregation benefits," *Information Systems Research* (15:1), 22-36.

Boudreau, K. J. 2010. "Open platform strategies and innovation: Granting access vs. devolving control," *Management Science* (56:10), pp. 1849–1872.

Boudreau, K. J. 2012. "Let a thousand flowers bloom? An early look at large numbers of software app developers and patterns of innovation," *Organization Science* (23:5), pp. 1409–1427.

Boudreau, K. J., and Jeppesen, L. B. 2015. "Unpaid crowd complementors: The platform network effect mirage," *Strategic Management Journal* (36:12), pp. 1761–1777.

Caillaud, B., and Jullien, B. 2003. "Chicken & Egg: Competition among Intermediation Service Providers," *The RAND Journal of Economics* (34:2), pp. 309–328.

Casadesus-Masanell, R., and Hałaburda, H. 2014. "When does a platform create value by limiting choice?" *Journal of Economics and Management Strategy* (23:2), pp. 259–293.

Ceccagnoli, M., Forman, C., Huang, P., and Wu, D. J. 2012. "Cocreation of Value in a Platform Ecosystem: The Case of Enterprise Software," *MIS Quarterly* (36:1), pp. 263–290.

Cennamo, C., and Santalo, J. 2013. "Platform competition: Strategic trade-offs in platform markets," *Strategic Management Journal* (34:11), pp. 1331–1350.

Claussen, J., Kretschmer, T., and Mayrhofer, P. 2013. "The effects of rewarding user engagement: The case of Facebook apps," *Information Systems Research* (24:1), pp. 186–200.

Clements, M. T., and Ohashi, H. 2004. "Indirect Network Effects and the Product Cycle : Video Games in the U . S ., 1994-2002," *Journal of Industrial Economics* (53:4), pp. 512–542.

Conte, T., Blau, B., and Xu, Y. 2010. "Competition of Service Marketplaces: Designing Growth in Service Networks," in *Eighteenth European Conference on Information Systems*, Pretoria, South Africa.

Corts, K. S., and Lederman, M. 2009. "Software exclusivity and the scope of indirect network effects in the U.S. home video game market," *International Journal of Industrial Organization* (27:2), pp. 121–136.

Eisenmann, T. R. 2008. "Managing Proprietary and Shared Platforms," *California Management Review* (50:4), pp. 31–54.

Eisenmann, T. R., Parker, G. G., and van Alstyne, M. W. 2009. "Opening Platforms: How, When and Why?" in *Platforms, Markets and Innovation*, A. Gawer (ed.), Cheltenham: Edward Elgar, pp. 131–162.

Eisenmann, T. R., Parker, G. G., and van Alstyne, M. W. 2011. "Platform Envelopment," *Strategic Management Journal* (32:12), pp. 1270–1285.

Evans, D. S. 2009. "How Catalysts Ignite: The Economics of Platform-Based Start-Ups," in *Platforms, Markets and Innovation*, A. Gawer (ed.), Cheltenham: Edward Elgar, pp. 99–128.

Evans, D. S., and Schmalensee, R. 2010. "Failure to Launch: Critical Mass in Platform Businesses," *Review of Network Economics* (9:4).

Farrell, J., and Saloner, G. 1985. "Standardization, Compatibility, and Innovation," *The RAND Journal of Economics* (16:1), pp. 70–83.

Gallaugher, J. M., and Wang, Y.-M. 2002. "Understanding network effects in software markets: Evidence from Web server pricing," *MIS Quarterly* (26:4), pp. 303–327.

Gawer, A. 2014. "Bridging differing perspectives on technological platforms: Toward an integrative framework," *Research Policy* (43:7), pp. 1239–1249.

Ghazawneh, A., and Henfridsson, O. 2013. "Balancing platform control and external contribution in third-party development: The boundary resources model," *Information Systems Journal* (23:2), pp. 173–192.

Ghazawneh, A., and Henfridsson, O. 2015. "A paradigmatic analysis of digital application marketplaces," *Journal of Information Technology* (30:3), pp. 198–208.

Ghose, A., and Han, S. P. 2014. "Estimating demand for mobile applications in the new economy," *Management Science* (60:6), pp. 1470–1488.

Hann, I.-H., Koh, B., and Niculescu, M. F. 2016. "The double-edged sword of backward compatibility: The adoption of multigenerational platforms in the presence of intergenerational services," *Information Systems Research* (27:1), pp. 112–130.

Hein, A., Böhm, M., and Krcmar, H. 2018. "Tight and Loose Coupling in Evolving Platform Ecosystems: The Cases of Airbnb and Uber," in *Business Information Systems: 21st international conference*: *BIS 2018*, W. Abramowicz and A. Paschke (eds.), Cham, CH: Springer, pp. 295–306.

Hilkert, D., Benlian, A., and Hess, T. 2010. "Motivational Drivers to Develop Apps for Social Software-Platforms: The Example of Facebook," in *Sixteenth Americas Conference on Information Systems*, Lima, Peru.

Huang, P., Ceccagnoli, M., Forman, C., and Wu, D. J. 2009. "When Do ISVs Join a Platform Ecosystem? Evidence from the Enterprise Software Industry," in *Thirtieth International Conference on Information Systems*, Phoenix, AZ, United States of America.

Huang, P., Ceccagnoli, M., Forman, C., and Wu, D. J. 2013. "Appropriability mechanisms and the platform partnership decision: Evidence from enterprise software," *Management Science* (59:1), pp. 102–121.

Huotari, P. 2017. "Too Big to Fail? Overcrowding a Multi-Sided Platform and Sustained Competitive Advantage," in *Fiftieth Hawaii International Conference on Systems Sciences*, Hawaii, United States of America, pp. 5275–5285.

Kang, S., and Lee, S.-Y. T. 2013. "Platform Market Share of Korean Online Game under Two-Sided Market with Low Switching Costs," in *Twenty-First Pacific Asia Conference on Information Systems*, Langkawi, Malaysia.

Kankanhalli, A., Ye, H. J., and Teo, H. H. 2015. "Comparing potential and actual innovators: An empirical study of mobile data services innovation," *MIS Quarterly* (39:3), pp. 667–682.

Katz, M. L., and Shapiro, C. 1985. "Network Externalities, Competition, and Compatibility," *The American Economic Review* (75:3), pp. 424–440.

Katz, M. L., and Shapiro, C. 1986. "Technology Adoption in the Presence of Network Externalities," *Journal of Political Economy* (94:4), pp. 822–841.

Katz, M. L., and Shapiro, C. 1994. "Systems Competition and Network Effects," *Journal of Economic Perspectives* (8:2), pp. 93–115.

Kazan, E., Tan, C.-W., Lim, E. T.K., Sørensen, C., and Damsgaard, J. 2018. "Disentangling Digital Platform Competition: The Case of UK Mobile Payment Platforms," *Journal of Management Information Systems* (35:1), pp. 180–219.

Koh, T. K., and Fichman, M. 2014. "Multi-Homing Users' Preferences for Two-Sided Exchange Networks," *MIS Quarterly* (38:4), pp. 977–996.

Li, M., Goh, K.-Y., and Cavusoglu, H. 2014. "Investigating Developers' Entry to Mobile App Platforms: A Network Externality View," in *Twenty-Second European Conference on Information Systems*, Tel Aviv, Israel.

Li, Z., and Agarwal, A. 2017. "Platform integration and demand spillovers in complementary markets: Evidence from facebook's integration of instagram," *Management Science* (63:10), pp. 3438–3458.

Manner, J., Nienaber, D., Schermann, M., and Krcmar, H. 2013. "Governance for Mobile Service Platforms: A Literature Review and Research Agenda," in *Eleventh International Conference on Mobile Business,* Delft, Netherlands.

Mantena, R., and Saha, R. 2012. "Co-opetition between differentiated platforms in two-sided markets," *Journal of Management Information Systems* (29:2), pp. 109–140.

Markovich, S., and Moenius, J. 2009. "Winning while losing: Competition dynamics in the presence of indirect network effects," *International Journal of Industrial Organization* (27:3), pp. 346–357.

McIntyre, D. P., and Srinivasan, A. 2017. "Networks, platforms, and strategy: Emerging views and next steps," *Strategic Management Journal* (38:1), pp. 141–160.

McIntyre, D. P., and Subramaniam, M. 2009. "Strategy in network industries: A review and research agenda," *Journal of Management* (35:6), pp. 1494–1517.

Oh, J., Koh, B., and Raghunathan, S. 2015. "Value appropriation between the platform provider and app developers in mobile platform mediated networks," *Journal of Information Technology* (30:3), pp. 245–259.

Ondrus, J., Gannamaneni, A., and Lyytinen, K. 2015. "The impact of openness on the market potential of multi-sided platforms: A case study of mobile payment platforms," *Journal of Information Technology* (30:3), pp. 260–275.

Parker, G. G., and van Alstyne, M. W. 2005. "Two-Sided Network Effects: A Theory of Information Product Design," *Management Science* (51:10), pp. 1494–1504.

Parker, G. G., van Alstyne, M. W., and Jiang, X. 2017. "Platform ecosystems: How developers invert the firm," *MIS Quarterly* (41:1), pp. 255–266.

Perrons, R. K. 2009. "The open kimono: How Intel balances trust and power to maintain platform leadership," *Research Policy* (38:8), pp. 1300–1312.

Reuver, M. de, Nederstigt, B., and Janssen, M. 2018a. "Launch Strategies for Multi-Sided Data Analytics Platforms," in *Twenty-Sixth European Conference on Information Systems*, Portsmouth, United Kingdom.

Reuver, M. de, Sørensen, C., and Basole, R. C. 2018b. "The Digital Platform: A Research Agenda," *Journal of Information Technology* (33:2), pp. 124–135.

Rochet, J.-C., and Tirole, J. 2006. "Two-sided markets: a progress report," *The RAND Journal of Economics* (37:3), pp. 645–667.

Rysman, M. 2009. "The Economics of Two-Sided Markets," *Journal of Economic Perspectives* (23:3), pp. 125–143.

Schirrmacher, N.-B., Ondrus, J., and Kude, T. 2017. "Launch Strategies of Digital Platforms: Platforms With Switching and Non-Switching Users," in *Twenty-Fifth European Conference on Information Systems,* Guimarães, Portugal.

Schreieck, M., Wiesche, M., and Krcmar, H. 2016. "Design and Governance of Platform Ecosystems – Key Concepts and Issues for Future Research," in *Twenty-Fourth European Conference on Information Systems,* Istanbul, Turkey.

Seamans, R., and Zhu, F. 2014. "Responses to entry in multi-sided markets: The impact of craigslist on local newspapers," *Management Science* (60:2), pp. 476–493.

Song, P., Xue, L., Rai, A., and Zhang, C. 2018. "The ecosystem of software platform: A study of asymmetric cross-side network effects and platform governance," *MIS Quarterly* (42:1), pp. 121–142.

Soto Setzke, D., Böhm, M., and Krcmar, H. 2019. "Platform Openness: A Systematic Literature Review and Avenues for Future Research," in *Fourteenth International Conference on Wirtschaftsinformatik,* Siegen, Germany.

Srinivasan, A., and Venkatraman, N. 2008. "The Role of Indirect Network Effects in Explaining Platform Dominance in the Video Game Industry (2002-2006): A Network Perspective," in *Twenty-Ninth International Conference on Information Systems*, Paris, France.

Staykova, K. 2018. "Managing Platform Ecosystem Evolution through the Emergence of Micro-strategies and Microstructures," in *Twenty-Sixth European Conference on Information Systems,* Portsmouth, United Kingdom.

Tan, B., Pan, S. L., Lu, X., and Huang, L. 2015. "The role of IS capabilities in the development of multi-sided platforms: The digital ecosystem strategy of alibaba.com," *Journal of the Association of Information Systems* (16:4), pp. 248–280.

Tanriverdi, H., and Chi-Hyon, L. 2008. "Within-industry diversification and firm performance in the presence of network externalities: Evidence from the software industry," *Academy of Management Journal* (51:2), pp. 381–397.

Tiwana, A. 2015. "Platform desertion by app developers," *Journal of Management Information Systems* (32:4), pp. 40–77.

Tiwana, A., Konsynski, B., and Bush, A. A. 2010. "Platform evolution: Coevolution of platform architecture, governance, and environmental dynamics," *Information Systems Research* (21:4), pp. 675–687.

Venkatraman, N., and Lee, C.-H. 2004. "Preferential linkage and network evolution: A conceptual model and empirical test in the U.S. video game sector," *Academy of Management Journal* (47:6), pp. 876–892.

Vom Brocke, J., Simons, A., Niehaves, B., Reimer, K., Plattfaut, R., and Cleven, A. 2009. "Reconstructing the Giant: On the Importance of Rigour in Documenting the Literature Search Process," in *Seventeenth European Conference on Information Systems,* Verona, Italy.

Wan, X., Cenamor, J., Parker, G., and van Alstyne, M. W. 2017. "Unraveling platform strategies: A review from an organizational ambidexterity perspective," *Sustainability (Switzerland)* (9:5), pp. 1–18.

Wareham, J., Fox, P. B., and Giner, J.L.C. 2014. "Technology ecosystem governance," *Organization Science* (25:4), pp. 1195–1215.

Webster, J., and Watson, R. T. 2002. "Analyzing the Past to Prepare for the Future: Writing a Literature Review," *MIS Quarterly* (26:2), pp. xiii–xxiii.

Wessel, M., Thies, F., and Benlian, A. 2017. "Opening the floodgates: The implications of increasing platform openness in crowdfunding," *Journal of Information Technology* (32:4), pp. 344–360.

West, J. 2003. "How open is open enough? Melding proprietary and open source platform strategies," *Research Policy* (32:7), pp. 1259–1285.

Yoo, B. 2005. "Outsourcing Game Software: A Longitudinal Study of Make or Buy Decisions in US Videogame Industry," in *Eleventh Americas Conference on Information Systems*, Omaha, NE, United States of America.

Yoo, B., Choudhary, V., and Mukhopadhyay, T. 2002. "A model of neutral B2B intermediaries," *Journal of Management Information Systems* (19:3), pp. 43–68.

Zhu, F., and Iansiti, M. 2012. "Entry Into Platform Based Markets," *Strategic Management Journal* (33), pp. 88–106.

Appendix B. (P2) The Engagement of Complementors and the Role of Platform Boundary Resources in e-Commerce Platform Ecosystems

Information Systems Frontiers
https://doi.org/10.1007/s10796-021-10236-3

The Engagement of Complementors and the Role of Platform Boundary Resources in e-Commerce Platform Ecosystems

Martin Engert[1] · Julia Evers[1] · Andreas Hein[1] · Helmut Krcmar[1]

Accepted: 21 December 2021

Abstract
The success of digital platforms can be attributed to the engagement of autonomous complementors as exemplified by e-commerce Content Management System (CMS) platforms such as WordPress and Shopify. Platform owners provide Platform Boundary Resources (PBRs) to stimulate and control complementor engagement. Despite the increasing scholarly interest in digital platform ecosystems, their exact role in facilitating and channeling complementor engagement remains unclear. Therefore, we conducted an embedded case study on CMS platform ecosystems, comprising a total of 24 interviews with platform owners and complementors. We inductively derive five types of complementor engagement and their respective manifestations and two overarching engagement goals of complementors. Moreover, we determine the different types of PBRs utilized, including their critical effects, and distinguish between uniform and individual PBRs reflecting their respective generalizability and scalability. We discuss the findings by introducing the concepts of complementor resourcing and complementor securing and shed light on the standardization-individualization tension of PBRs faced by platform owners.

Keywords Digital platform ecosystems · Complementor engagement · Platform boundary resources · Content management systems · e-Commerce · Case study

1 Introduction

In recent decades, incited by digitalizing products, services, and processes, digital platform ecosystems have emerged as a dominant economic model (Cusumano et al., 2020; Hein et al., 2019b; Soto Setzke et al., 2021). The continued growth of the e-commerce sector, for instance, can be attributed to the role of content management system (CMS) platforms, such as WordPress and Shopify, and their respective ecosystems. They allow online merchants to create, manage and expand their online stores, thus to compete with online retail giants, such as Amazon or Alibaba. CMS platforms are digital platforms and provide a technological core that is being augmented by modules developed by a diverse ecosystem of independent third parties (commonly referred to as *complementors*), extending the platform's core functionality (De Reuver et al., 2018; Tiwana et al., 2010). As such, Shopify relies on complementors to provide additional functionalities to their e-commerce CMS platform, with its integrated app store comprising almost 6000 applications in 2021.[1] Together with the ecosystem of complementors, the Shopify platform serves the needs of 1.7 million online merchants in 2020.[2]

Hence, the potential for the success of digital platform ecosystems lies in the fact that they are based on the contributions of complementors. Complementor activities spur generativity across the ecosystem, bringing the products and services offered to scope and scale, which are difficult to replicate within a single organization (Hein et al., 2019a; Parker et al., 2017). Cooperative partnerships and strategic alliances have been a commonly used format for dealing with market challenges such as complex customer needs for over three decades (Drucker, 2003; Harvey & Lusch, 1995). However, complementors are autonomous actors in platform ecosystems who engage with the platform with limited contractual obligations. Hence, they invest resources only if it enables them to provide a more compelling value proposition to their customers and if they can capture that value (Kude

✉ Martin Engert
martin.engert@tum.de

1 KrcmarLab, Department of Informatics, Technical University of Munich, Boltzmannstrasse 3, 85748 Garching, Germany

1 https://apps.shopify.com

2 https://news.shopify.com/shopify-announces-fourth-quarter-and-full-year-2020-financial-results#

Published online: 03 January 2022

et al., 2012; Rickmann et al., 2014). *Complementor engagement* describes their different ways and forms of interacting with the platform according to their intended objectives and ambitions. Complementor engagement encompasses not only the development of applications but also collaboration among complementors, exchange of knowledge, testing new platform features, or selling the platform to users (Foerderer et al., 2019; Saadatmand et al., 2019; Wareham et al., 2014). With these various engagements, complementors represent a vital source of information and resources for a platform's scalability, growth, and competitive sustainability (Jacobides et al., 2018; Wan et al., 2017).

CMS platforms provide many resources to stimulate and enable complementors to engage with the platform and all other actors within the ecosystem. They include Application Programming Interfaces (APIs) for billing processes in their applications or forums to interact with customers and other complementors. Research on digital platform ecosystems refers to these as *platform boundary resources* (PBRs), either technical or social PBRs. Technical PBRs comprise APIs or Software Development Kits (SDKs), supporting applications and their development (Bianco et al., 2014; Eaton et al., 2015; Ghazawneh & Henfridsson, 2013). Besides technical PBRs, platforms also provide social PBRs ranging from documentation to interactive forums and hackathons (Bianco et al., 2014; Foerderer et al., 2019). Recent research has devoted particular attention to questions concerning the adequate design of technical PBRs and their role in balancing openness and control from the perspective of the platform owner (Hein et al., 2019a; Karhu et al., 2018). Some researchers have also investigated the ongoing (re) design of PBRs between complementors and the platform owner and complementor satisfaction with them (Eaton et al., 2015; Petrik & Herzwurm, 2020a). Hence, PBRs represent one of the critical elements in creating a successful digital platform by facilitating complementor engagement in general (Petrik & Herzwurm, 2020a, b).

However, given the centrality of PBRs in managing the's length relationship with complementors and the scholarly attention to the topic, there is little knowledge of the concrete role of PBRs in facilitating different complementor engagements. While extant research informs platform firms on the importance of PBRs, their relation to the engagement of complementors as the driver of a platform's generativity and growth remains unknown (Petrik & Herzwurm, 2020a). The standardization of PBRs is a prerequisite to the scalability of the platform ecosystem enabling engagement of all complementors, while individualized PBRs can increase engagement of single complementors (Hein et al., 2019c). Hence, Shopify and other platform firms benefit from a deeper understanding of the application of standardized and individualized PBRs and their respective roles for complementor engagement. In essence, such knowledge will allow platform firms to strategically employ standardized and individualized PBRs to stimulate and steer complementors' collective and individual engagement.

Moreover, the connections between the types of PBRs and the different engagement interactions of complementors contribute to striking a balance between openness and control of external contributions (Boudreau, 2010; Ghazawneh & Henfridsson, 2011, 2013). Further, the use of PBRs for different engagement types informs the development of complementor strategies and clarifies the nature of their platform dependency (Cenamor, 2021; Nambisan et al., 2018). Therefore, we pose the following guiding research question to be explored with the current study:

What is the role of platform boundary resources in complementor engagement of digital platform ecosystems?

To answer this research question, we build on an embedded case study in the context of e-commerce CMS platform ecosystems (Eisenhardt, 1989; Yin, 2018), constituting one of the fastest growing and fragmented platform markets. More precisely, we apply a two-step research approach. In the first step, we conduct interviews with nine different CMS platforms representatives to overview the overall setting and the platform owner perspective. In the second step, we focus on three of these CMS platforms (namely WordPress, Magento, and Shopify) and conduct 15 interviews with complementors affiliated with them to gain insights into how they engage with the platforms and the role of PBRs to account for the complementor perspective. Notably, 12 of the complementors offer their applications on all three CMS platforms, strengthening the generalizability of our findings for the context of e-commerce CMS platforms.

Based on an inductive analysis of the interview data (Glaser & Strauss, 1967), we create an in-depth understanding of the interactions between the platforms and their respective complementors via the provided PBRs. First, our results yield insights into five types of complementor engagement: developing products, ensuring compliance, enhancing products, commercializing products, *and cooperating* in addition to their respective manifestations. Further, *alignment with the platform* and *driving innovation and success* emerged as the two engagement goals of complementors. Second, we determine the PBRs that complementors utilize for each engagement manifestation and distinguish between uniform and individual PBRs.

The resulting framework provides a much-needed step toward an integrated perspective of PBRs and their role in engaging an ecosystem of complementors. The current paper thus contributes to the literature on digital platform ecosystems by broadening the perspective on PBRs as facilitators of complementors' strategic engagement. By introducing the novel concepts of complementor resourcing and complementor securing, the results of the current study emphasize the original notion of PBRs enabling resourcing and securing processes (Ghazawneh & Henfridsson, 2013). They represent the complementor perspective in the interactive process of shaping and reshaping PBRs termed "distributed tuning," as Eaton et al. (2015) suggested. Finally, we shed light on the standardization-individualization tension of PBRs faced by platform owners. Practitioners benefit from an integrated perspective on PBRs and their role in engaging complementors, allowing them to make informed decisions concerning PBR provision and developing strategies for complementor engagement around them.

2 Theoretical Background – Digital Platform Ecosystems

Following Tiwana et al. (2010), digital platforms represent an extensible codebase, which provides core functionality extended by interoperable modules. These modules are software-based add-ons, such as applications in the mobile application marketplaces of Apple and Google (Ghazawneh & Henfridsson, 2015; S. Wang et al., 2008). The interconnectedness and necessary interoperability between the modules and the platform results in considerable dependency, leading to increased coordination costs on the part of the developers of the modules (Tiwana, 2015). Platform owners, in turn, face the challenge of defining standards and procedures that increase the openness for external contributions while keeping control over the platform core (Boudreau, 2010, 2012). Prior work has primarily devoted considerable attention to this situation by taking the platform owner's perspective and investigating platform governance and design (Lima Fontão et al., 2019; Schreieck et al., 2021).

At its core, platform governance focuses on answering the questions concerning "who makes what decisions about a platform" (Tiwana et al., 2010, p. 679). Hence, platform governance considers a broad variety of topics. For instance, it comprises the design and implementation of the rules for admitting complements to the platform application marketplace, summarized as input control (Lima Fontão et al., 2019; Tiwana, 2014). Besides enacting top-down rules, platform owners provide resources to complementors to stimulate and enable their contributions. These affordances provided by the platform owner to complementors take the form of PBRs (Constantinides et al., 2018; Hein et al., 2019a). Thus, PBRs, such as SDKs, allow complementors to develop applications on top of the software-based platform with minimal effort. Thereby, the quality of the PBR is one of the most critical factors for complementors (Koch & Kerschbaum, 2014; Petrik & Herzwurm, 2020a). The conceptual origin of PBRs, the different types, and their relation to complementary resource contributions will be outlined in more detail in the following sections.

From a socio-technical view, platform ecosystems are considered structures of inter-firm relations that interact for a focal value proposition to emerge (Adner, 2017). In their recent literature review guided by socio-technical systems theory, K. Kapoor et al. (2021) provide an extensive overview of the socio-technical view of platform ecosystems. They integrate the four dimensions of socio-technical systems, namely technical aspects, tasks, actors, and structures, and derive an extensive research agenda for platform ecosystem research around them. One of their key findings relates to the platform owner's responsibility to develop "incentive mechanisms not only to attract competent complementors but also to maintain lasting relationships with them" (K. Kapoor et al., 2021, p. 99). Since digital platform ecosystems comprise diverse actors, mainly distinguished along the lines of complementors, users, and the platform owner, the management of relationships with other actors is considered a critical success factor (Floetgen et al., 2021; Hein et al., 2019a). Therefore, engaging other users and complementors has received increased attention (Saadatmand et al., 2019). Engagement in the context of digital platform ecosystems is considered an actor's contribution of resources, such as time, knowledge, and relationships toward the ecosystem and its associated actors (Yu & Ramaprasad, 2019). Hence, engagement is the foundation for value cocreation among complementors and the platform owner (Saadatmand et al., 2019; R. D. Wang & Miller, 2019). We will outline aspects concerning the role of complementors within the ecosystem, their motivations, and strategies in more detail during the following sections.

2.1 Platform Boundary Resources

Building on the boundary objects theory (Bharosa et al., 2012; Star, 2010), the concept of PBRs was introduced to research on digital platform ecosystems to denote resources that allow the platform owner to govern complementary software development (Ghazawneh & Henfridsson, 2010). Following the definition by Ghazawneh and Henfridsson (2013, p. 174), PBRs are defined as "the software tools and regulations that serve as the interface for the arm's-length relationship between the platform owner and the application developer." Prior studies identified different PBRs and distinguished between application boundary resources, development boundary resources, and social boundary resources (Bianco et al., 2014; Petrik & Herzwurm, 2020a). Application boundary resources allow third-party applications to connect with the platform core, including APIs for accessing specific data (Grzenda & Legierski, 2021). Development boundary resources provide the means to developers to develop their applications, such as SDKs or debugging tools. These are supported by social boundary resources which comprise documentation, support contacts, or developer forums (Bianco et al., 2014). The platform's scalability depends on the availability of standardized PBRs, such as APIs, while catering to individual needs of complementors via individualized resources comprising support contacts (Hein et al., 2019c; Huber et al., 2017).

By providing PBRs to complementors, the platform owner can fuel generativity within the ecosystem via *resourcing* while maintaining control over the platform core via *securing* (Ghazawneh & Henfridsson, 2013). That way, PBRs allow the platform owner to balance control and external contribution, mediating between the various parties (Boudreau, 2010; Kannisto et al., 2020). However, PBRs are not exclusively created by the platform owner: when complementors perceive them as limited, they may build PBRs themselves via *self-sourcing* (Eaton et al., 2015; Ghazawneh & Henfridsson, 2013). Moreover, PBRs can provide an entry point for hostile attacks, such as forking, emphasizing the importance of balancing openness and control to sustain the platform's competitive advantage (Karhu et al., 2018). In their seminal work, Eaton et al. (2015) investigated the dynamic process of platform owners and complementors in shaping and reshaping PBRs. The authors find that PBRs are artifacts shaped by the interactions between the platform owner and complementors over time. Hence, how complementors engage with the platform and the platform owner determines the presence and shape of the PBRs in digital platform ecosystems and vice versa.

2.2 Engagement of Autonomous Complementors

Critical to the sustained success of multi-sided platform ecosystems is a platform's ability to attract complementors or, more precisely, external software providers that build complementary software applications or module extensions on top of the platform's technological infrastructure (Ceccagnoli et al., 2012; Engert et al., 2019). Such engagement of complementors forms a symbiotic partnership between platform and complementor that is beneficial to both sides through value cocreation (Zhang et al., 2021). On the one hand, platform ecosystems benefit from a functional extension that adds significant value to end customers through specific software solutions (Engert et al., 2021). On the other hand, complementors can integrate their products into the offering of a broader platform, thus increasing the attractiveness of their value proposition(s) for customers (Adner, 2017; Cennamo & Santalo, 2019).

However, complementor engagement transcends the idea of mere app development by complementors. It captures their different ways and forms of interacting with the platform according to their intended objectives and ambitions. More precisely, complementors are autonomous actors who engage with the platform purely out of self-interest and invest their resources (such as their time, know-how and effort) in value co-creating activities only if it enables them to provide a more compelling value proposition to their customers and if they can capture that value (Kude et al., 2012; Rickmann et al., 2014). By having agency, it is evident that complementors differ significantly in terms of their strategy, resources, and capabilities (Helfat & Raubitschek, 2018; Lusch & Nambisan, 2015). As such, complementors can be distinguished according to their various roles within the ecosystem. In addition to development-oriented activities, complementors may, for example, also be involved in service-oriented activities aimed at implementing and integrating the software or its extended modules into the end customer's IT infrastructure. Other complementors may deliver consulting services focusing on adapting and customizing the generic software according to customers' specific needs in the various industry segments (Wareham et al., 2014). Additionally, their agency allows them to affiliate with only one platform, referred to as "single-homing" or multiple platforms at the same time, referred to as "multihoming" (Armstrong, 2006). An app developer, for instance, offering their app on both the Google Play Store and the Apple App store is multihoming.

The heterogeneity among complementors and their diverse interactions with the platform complicate the platform owner's attempts to manage and orchestrate the ecosystem. It requires continuous investments in the design and adaptation of the underlying platform to enable value-adding interactions among actors in the ecosystem through PBRs and the implementation of governance mechanisms on the part of the platform owner (Lima Fontão et al., 2019; Tiwana et al., 2010). PBRs, therefore, represent a means or mechanism that facilitates the sharing of resources or knowledge and establishes the foundation and boundaries for resource contributions by various entities, such as complementors (Hein et al., 2019a; Karhu et al., 2018).

Depending on the provision and design of the resources and how complementors perceive them, there may be different implications for complementor engagement (Petrik & Herzwurm, 2020a). For example, technical PBRs, such as APIs or SDKs, enable complementors by affording access to the platform's technology. Others, such as the supply of training, certifications, or documentation, aim at knowledge transfer from the platform owner to the complementor and allow an expanded perspective to the mere enablement through a more application-oriented focus (Foerderer et al., 2019). Another critical use of PBRs lies in their potential to motivate and incentivize complementors to interact and commit to the platform ecosystem on an ongoing basis (Schulz et al., 2020; Zhang et al., 2021). Examples are manifold, including supporting successful complementors with dedicated individual resources, such as customer referrals that further enhance their positioning and differentiation within the network (Cenamor, 2021; Huber et al., 2017). Lastly, the ways complementors use and engage with PBRs provided by the platform owner has consequences for their design, giving rise to the distributed tuning of PBRs (Eaton et al., 2015).

To date, however, the scientific debate has not conceptualized the types of complementary engagement within platform ecosystems and the facilitating role of PBRs. This knowledge serves to answer questions concerning the dependency of complementors and explain their strategic engagement with specific platforms. Exploring the use of different PBRs may inform platform owners on the importance of specific PBRs. This is particularly concerning which engagement types build on standardized PBRs and which depend on individual PBRs. These issues are to be addressed with the current work.

3 Research Approach

Recognizing the lack of studies to advance our understanding of the role of PBRs in engaging complementors in digital platform ecosystems, we conduct an embedded case study of CMS platform ecosystems in the e-commerce industry (Eisenhardt, 1989; Yin, 2018). With a projected global sales volume of $4.2 trillion in 2021, e-commerce represents one of the largest markets created by the rise of digital technologies, making it an intriguing research setting.[3] The chosen research approach is particularly suitable to investigate complex and contemporary phenomena, such as digital platform ecosystems, PBRs, and the engagement of complementors. To that end, we apply a qualitative two-step research design comprising 24 semi-structured interviews as the primary data source.

First, we conduct interviews with nine different e-commerce CMS platform owners to gain an in-depth understanding of the research setting and the perspective of various platform owners on the provision of PBRs and the engagement of complementors. In a second step, we focus on three e-commerce CMS platforms (WordPress, Magento, and Shopify), interviewing 15 representatives of complementor organizations. The selected units of analysis are all successful and mature platforms, having attracted and engaged large numbers of complementors to their ecosystem. The chosen subunits differ regarding their ownership and governance structure, with WordPress being open-source, Magento being formerly open-source, and in transition to a closed platform after being acquired by Adobe and Shopify being a closed platform. Importantly, our study aims to identify the commonalities across platforms as units of analysis within the broader context of e-commerce CMS platforms.

Overall, the employed case study focuses on different types of complementor engagement and the PBRs provided by platform owners while aiming to understand the role of PBRs in complementor engagement in the e-commerce context in general. The following section introduces the role of CMSs in the e-commerce sector and showcases their properties as digital platform ecosystems.

3.1 e-Commerce Content Management Systems as Platform Ecosystems

In e-commerce, online merchants are the platform's customers, running online shops that build on CMSs. Various e-commerce solution providers acting as platform owners of CMS platforms, such as WordPress, Magento, and Shopify, address this need. Plugins created by third-party developers expand the core functionality of the CMS, thus taking on the role of third-party developers. The complementors utilize PBRs to build and promote their plugins, which are extensions that can be downloaded and installed by online merchants into their platform instantiations, which are their online shops. Typical plugins are, for instance, payment solutions (e.g., Alipay, Amazon Pay) or apps for the online merchant to interact with consumers, such as chat programs or chatbots. We selected three different platforms to understand better complementor engagement and the role of PBRs: WordPress, Magento, and Shopify. Table 1 briefly describes each subunit:

3.2 Data Collection

Concerning our primary data collection, we first conducted interviews with nine representatives from platform owners (P1 to P9) for an average of 32 min each (see Table 2). Interviews were conducted under the premise of anonymity; thus, we pseudonymized the platforms as platforms 1 through 9. Our interview questions and the selection of roles focused on the interactions with complementors and the role of PBRs in enabling and managing these interactions. Significantly, in the case of open-source platforms, the platform owner was represented by members of the open-source community. After this round of interviews, we chose three platforms, WordPress, Magento, and Shopify, based on the following rationale: We aimed at selecting three mature platforms with a large number of partners (using the number of available apps in the app store as a proxy), making it necessary to provide a large number of scalable and personal PBRs. Besides, we chose one open-source platform (WordPress) and one proprietary platform (Shopify). We added a third currently open-source platform that is transitioning to a proprietary

[3] https://www.forbes.com/sites/joanverdon/2021/04/27/global-ecommerce-sales-to-hit-42-trillion-as-online-surge-continues-adobe-reports/

Table 1 CMS platforms as units of analysis included in the embedded case study

CMS platform	Brief description
WordPress *(free and open-source)*	**WordPress** is a free and open-source CMS platform initiated in 2003. Originally designed to serve as a publishing system, mainly for blogs, but evolved to serve various web functionalities, such as forums, e-commerce, and media galleries. It is the most prominent CMS globally, accounting for about 42% of the entire web (W3Techs, 2021). Due to its open nature, there are no business-level agreements, partner programs, accountancy requirements, or financial incentives. However, it includes a plugin architecture with approximately 59.000 plugins in its marketplace in mid-2021.[a] Notably, plugins can be installed freely, but to use their features, users may need to subscribe to a paid plan or other modes of payments as requested by the respective developer.
Magento *(open-source acquired by Adobe and in transition to closed)*	**Magento** is an open-source e-commerce digital platform founded in 2008. In 2018, it was acquired by Adobe. Thus, there are both free (Magento Open Source) and paid versions (Magento Commerce, Magento Commerce (on-site)). Magento powers approximately 1.1% of the entire web (W3Techs, 2021). The platform has a marketplace for extensions, which allows users to extend and enhance the capabilities of the Magento platform. There are about 3900 extensions available in the marketplace, which can be free or paid via the Magento marketplace.[b]
Shopify *(paid and closed)*	**Shopify** is a paid and closed-source e-commerce platform that was founded in 2004. Shopify offers online stores a set of services, including payment management, marketing, shipping, and customer engagement tools, to simplify the management of an online store for small merchants. Shopify accounts for 5.5% of CMS used in the entire web, making it the second biggest CMS besides WordPress (W3Techs, 2021). There are close to 6000 apps on its marketplace as of mid-2021, making Shopify the most crowded marketplace among its competitors.[c]

[a]https://wordpress.org/plugins/

[b]https://marketplace.magento.com/

[c]https://apps.shopify.com

Table 2 Overview of interviews with platform owner representatives

Interviewee	Role	Platform (pseudonymized)	Duration
P1	Integrations Manager	Platform 1	32 min
P2	Head 3rd Party Developer Ecosystem	Platform 2	35 min
P3	Strategic Partnerships Director	Platform 3*	28 min
P4	Head of Developers Platform	Platform 4	43 min
P5	Director of Technology Partnerships	Platform 5	31 min
P6	Head of App Market	Platform 6	39 min
P7	Partnership Manager	Platform 7*	38 min
P8	Business Development Manager	Platform 8*	38 min
P9	CEO, Co-founder	Platform 9	33 min

*platform is part of the three selected cases WordPress, Magento, and Shopify

status as an intermediate case (Magento). The characteristics of all platforms are displayed in Appendix 1.

Subsequently, we conducted 15 interviews with representatives of complementor organizations associated with the three platforms under investigation, focusing primarily on roles related to the technical integration of applications with the platform (see Table 3). As shown in Table 3, 12 of the complementors offer their applications on all three CMS platforms, strengthening the generalizability of our findings for the context of e-commerce CMS platforms. Interview questions focused on interactions with and the expectations toward the platform. The average interview length for complementors is 38 min.

All interviews were conducted between early and mid-2020 using semi-structured interview guidelines. Appendix 2 provides an overview of the interview guidelines. Each interview was recorded and transcribed to enable structured data analysis. We further investigated secondary data, such as websites, corporate blogs, and whitepapers to triangulate our findings.

3.3 Data Analysis

To analyze the data, the research team followed structured coding procedures comprising open, axial, and selective coding, switching between the data and the emerging theory

Table 3 Overview of interviews with complementors

Interviewee	Role	Affiliated Platform Ecosystems			Duration
		WordPress	Magento	Shopify	
C1	Integrations Developer Team Lead	x	x	x	41 min
C2	CEO, Founder	x	x	x	46 min
C3	Integrations Developer	x	x	x	38 min
C4	Business Development Manager	x			32 min
C5	CTO	x	x	x	24 min
C6	Tech Lead	x	x	x	33 min
C7	Senior Developer		x		34 min
C8	Integrations Manager	x	x	x	41 min
C9	Partnerships Specialist	x	x	x	35 min
C10	Integrations Developer	x	x	x	31 min
C11	Lead of Integrations Team	x	x	x	51 min
C12	Growth Hacker	x	x	x	27 min
C13	Integrations Developer	x	x	x	56 min
C14	Head of Marketing	x	x	x	39 min
C15	Platform Integration Specialist			x	43 min

(Glaser & Strauss, 1967). Table 4 uses an example to illustrate our coding steps.

We coded both dimensions to capture complementor engagement and their relation to PBRs while making additional notes and memos. We started openly coding the interviews and identified 103 codes of different instances for complementor engagement. In a second step, we engaged in axial coding and created 32 codes for different complementor activities. Thirdly, we switched to selective coding, firstly (I) integrating the activities in ten engagement manifestations and secondly (II) determining the five engagement types from the engagement manifestations as our final results. The research team iterated between the levels to ensure that higher-level codes aligned with the underlying data.

While coding complementor engagement, the team collected the PBRs mentioned by interviewees in the context of each engagement (see bold marks in Table 4). These PBRs were then categorized as uniform or individual as part of a separate coding procedure by two research team members. Discussions helped clarify ambiguous PBRs, such as hackathons, which were coded as "individual" PBRs due to their restricted accessibility for complementors. In addition, the research team coded the critical effects of each PBR on complementors' engagement, which relate to innovation, governance, and communication between the platform owner and complementors.

4 Results

The current study provides insights into complementor engagement and the role of PBRs in supporting and enabling the different types of engagement. Our data suggests five types of complementor engagement: *developing products, ensuring compliance, enhancing products, commercializing products, and cooperating*. For each complementor engagement type, we determine two engagement manifestations. For each manifestation, we collect the respective PBRs through which complementors engage and distinguish them according to their uniform or individualized nature and their critical effects on complementors' engagement. As such, *uniform PBRs* reflect standardized one-to-many resources, such as documentation, APIs, and various tools to be used by every complementor without individual adjustments.

In contrast, *individual PBRs* comprise one-to-one and one-to-few resources, such as personal contacts, hackathons, or individual promotions, available to single complementors or selected groups of complementors. Table 5 presents examples for uniform and individual PBRs identified from our data and their respective effects on complementor engagement. Appendix 3 provides a detailed overview of all engagement types, manifestations, and the associated PBRs.

Lastly, two engagement goals emerge from the engagement types: complementors *ensuring platform alignment* while also aiming to *drive innovation and success* concerning their products and services offered via the CMS platforms. Figure 1 summarizes our results based on the categories mentioned above. For instance, the engagement manifestation *troubleshooting* is a subset of *enhancing products*. For troubleshooting, complementors utilize uniform PBRs, including testing and debugging tools and individual PBRs, such as live chats and personal contacts.

The following sections present the results according to the engagement goals, the engagement types associated with these goals, and each type's manifestations. The PBRs utilized are highly interrelated with each engagement

Table 4 Exemplary coding of complementor engagement and associated PBRs

Exemplary Interview Data (Open Codes underlined)	Complementor Activities (Axial Codes)	Engagement Manifestations (Selective Codes I)	Engagement Types (Selective Codes II)	Associated PBRs
"[…] and our objective was to find new platforms to integrate our product on. […] But the problem was they were lacking key functionalities that are essential for us. After a few ***emails****, we* ***called*** *their product team to suggest them working on building these gateways."* (C1)	• Inquiries to extend the functionality to enable new product integrations	• Technical Requests	• Enhancing Products	• Emails • Personal contacts

manifestation and therefore presented alongside the manifestations.

4.1 Engagement Goal: Ensure Platform Alignment

One goal complementors pursue when engaging with digital platforms is to ensure the platform's alignment concerning technical, legal, and other regulatory aspects. To that end, complementors utilize PBRs to ensure technical integration and alignment with technical requirements. Additionally, complementors ensure compliance with their products and business approach from a legal standpoint, such as financial reporting standards and compliance with platform-specific regulations, such as payment processing. PBRs, such as APIs and the SDK, allow complementors to overcome technological ambiguities while terms and conditions and agreements support their efforts to ensure compliance.

4.1.1 Developing Products

Product development encompasses all complementor activity related to developing their products within the standards and prerequisites of the platform in a technical sense. Complementors engage in integration and ensure their alignment with technical requirements.

Technical Integration To integrate their products with the platform, complementors interact with the platform to understand its infrastructure, its architectural configuration, and the technological environment's overall dynamics. In this regard, C6 describes that they *"[…] first need to study the documentation and API […]"* because *"[…] all in all, you need to acknowledge the environment*." Part of becoming familiar with the platform is understanding the dependencies of the modules that complement the platform's core functionality. Interview partner C15 expresses that *"[…] the biggest challenge is to make sure that the app works for every user in every case"* and that this is particularly complex when there are many interdependencies of platform modules. To make the best use of the platform's capabilities, complementors take advantage of the learning opportunities that are either freely available or are limited to specific partners who can receive exclusive certifications. Generally, these training programs help understand necessary details to increase the product's quality significantly.

To that end, platform owners open and provide access to the platform in a technical sense and allow complementors to use the basic platform functionalities for application development. The relevant PBRs are standardized for all complementors and range from providing APIs and software development tools, such as compilers and debuggers via SDKs, to sandboxes and testing environments. Moreover,

Table 5 Examples for uniform and individual PBRs and their critical effects

Platform Boundary Resources	Examples and critical effects of PBRs from CMS platforms		
	Innovation-oriented PBRs	Governance-oriented PBRs	Communication-oriented PBRs
Uniform PBRs	API, SDK (debuggers, compilers), benchmarking tools, market intelligence, and platform ecosystem briefings	documentation, guidelines, tutorials, videos, trainings, design specifications, privacy policies, prefabricated marketing materials	monthly townhalls, forums, stack exchange, newsletters, blogs
Individual PBRs	hackathons, workshops, early access programs (alpha and beta)	listings on the marketplace, cost-per-click campaigns	personal contacts, live chats, emails, phone contacts, featured blog postings, events

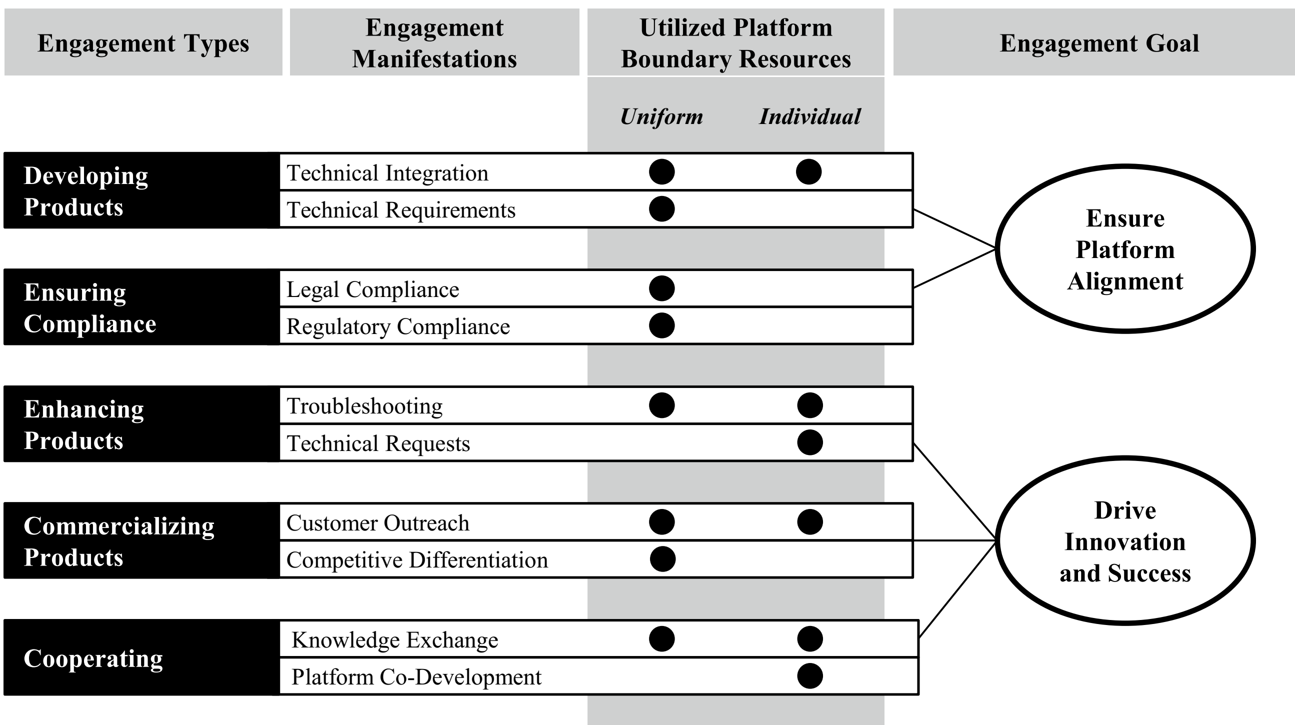

Fig. 1 Overview of complementor engagement and utilized platform boundary resources

documentation, guidelines, tutorials, videos, and training introduce complementors to the platform's infrastructure and dynamics and generate a shared understanding of platform functionalities and their possibilities. P5 reports that to *"provide some build-and-break tools, we give them a sandbox environment; we even share some pieces of our source code for interfaces."* Moreover, these resources target complementor representatives in different roles, such as administrators, technical experts, or functional experts, and thus differ in their depth of technical content.

Technical Requirements Throughout product development, complementors invest considerable resources to adhere to the platform owner's technical requirements, such as design specifications and code quality standards. As such, complementors submit their applications to certification processes that ensure the quality and functionality of the products as required by the platform owner before their release to the application marketplace. Interviewee C5 describes that *"even small things like image quality requirements can be challenging at times […], you cannot just go with what you have in hand; you have to obey the rules of the platform."*

Platform owners communicate code quality standards, design specifications, testing procedures, and the app certification process via widely accessible blogs, websites, and documentation to align with technical requirements. Complementors must pay attention to how the platform evolves. C3 reports that this situation requires particular engagement on their part: *"[…] platforms have different requirements,* *and it can easily become a challenge for us. […] Imagine you are in the midst of something, and suddenly you get an email saying that '[the] SDK version that you use will be depreciated in two weeks.' We study the new SDK and negotiate to get more time […]."*

4.1.2 Ensuring Compliance

Many of the complementors' efforts are concerned with ensuring compliance with the legal and regulatory realities of the platform and overarching legislation, such as the European GDPR [General Data Protection Regulation].

Legal Compliance Legal compliance describes the measures taken by complementors to comply with legal requirements established by different legislators, such as prevailing privacy laws that even go beyond the platform's sphere of influence. Especially after the mid-2010s, awareness of data protection and privacy has progressively increased, resulting in more regulations and severe sanctions. The statement made by C2 highlights the impact of having to engage with such privacy regulations actively: *"GDPR was another shock wave for the ecosystem. I mean, there were privacy policies before, […] but it was a paradigm shift. Before even starting to build products, most people go through a privacy checklist and build the product with respect to that. Also, legal consultants came into our lives; they are in the game—always. Whenever we have a new column in our database, we brief our consultant, the platform's legal department, we update our privacy policy, and so on."*

Hence, platform owners also need to support complementor compliance with legal requirements. Platform owners work intensely to provide the necessary PBRs to increase the transparency of regulations for complementors. Standardized documentation and other materials, such as terms and conditions agreement, proprietary right agreements, privacy policy statements, are being created by the platforms' legal departments, which help 8020 communicate and formulate legal frameworks and procedures.

Regulatory Compliance Beyond technical requirements, we find that complementors invest resources to adhere to the platform's organizational policies and regulations. One such aspect relates to financial transaction management, including participation and hosting fees, financial reporting standards, end-customer payment processing, and corresponding invoice management. Furthermore, mutual agreements need to be respected to maintain trust between the parties. C2 stresses the importance of compliance: *"What we do is to make sure our legal team analyzes any agreements, and only then [do] we move forward with signing and performing it."*

To support complementors' engagement with platform-related rules, platform owners offer standardized PBRs, including agreements, clarifications of property rights, privacy policies, conflict resolution procedures, and enforcement procedures. The provision of PBRs aims to support complementor financial operations, such as payment processing, transaction management, and financial reporting standards. P9 suggests that the scalability and size of the platform require the provision of standardized PBRs to ensure compliance of all complementors: *"[…] hundreds of transactions happen every day in the app marketplace and these are due to being reported, I mean we have obligations to report to authorities. […] We also process all payments on our side, so before leaving the shares to complementors, we pay their taxes as well and then pay them. Otherwise, I mean, if they do not pay their taxes, that will be a problem for us."*

4.2 Engagement Goal: Drive Innovation and Success

The second goal pursued by complementors when engaging with digital platforms is to steadily innovate their products and services, resulting in increased business success usually measured in app downloads. Therefore, complementors enhance their products by solving technical challenges or requesting missing platform features. Complementors additionally engage in commercial activities related to customer outreach and competitive differentiation from other products and services on the platform. At the same time, complementors cooperate with their peers to exchange knowledge and with the platform owner to co-develop the platform. Via PBRs, the platform motivates complementor engagement, such as early access programs, personal contacts, or tools for complementors to benchmark their standing in the marketplace, reducing complementor uncertainty.

4.2.1 Enhancing Products

Ongoing development of their products and services is fundamental for enduring business success in competitive environments such as CMS platforms' application marketplaces. Hence, complementors are maintaining and extending their products, which manifests in troubleshooting issues and requesting new platform features.

Troubleshooting Complementors are busy ensuring their products' ongoing functionality, requesting technical support in case of difficulties, often in light of major platform updates. To do so, complementors emphasize the importance of platforms offering advanced testing and debugging capabilities. These ensure that in the event of failure, the complementor is not *"[…] in no man's land"* (C11).

Complementors also simulate different scenarios using these standard PBRs to test whether their products work for customers. However, as C5 explains, these standardized PBRs are not always sufficient: *"[…] [the platforms] provide resources, guidelines, documentation but it is not always enough or you just simply cannot find the answer to your specific problem*." In these situations, complementors engage with platforms' one-on-one assistance when encountering technical difficulties with their applications and the platform technology. C7 points out that the platform owner "*[…] should provide responsive support 24/7. Not every platform offers that, but I think it is crucial. Bugs happen and they happen often. Sometimes we need help from their side […].*"

Overall, platform owners provide a broad range of PBRs to complementors to help them with technical issues. These comprise individualized PBRs such as live chats, emails, and phone contacts, as well as standardized PBRs such as forums or stack exchanges. In general, P5 emphasizes that it is vital to be responsive to the needs of complementors and that they *"[…] try to support them whenever they need help, say, to solve a technical issue or they wonder about a concept and could not figure it out. Yes, we should be there; otherwise, they will go elsewhere."* On top of that, the platform owner proactively informs complementors of changes and updates to the platform via standardized newsletters, changelogs or monthly town halls to prevent issues.

Technical Requests Another way complementors engage with the platform is to give feedback on its capabilities and actively ask for enhancements to accommodate their needs. These technical requests concern additional information, resources, or platform features that allow complementors to improve the performance of their products or extend the functionality and applicability of their solutions. C15 elaborates that *"[…] our focus is to be innovative with our product. We just ask for more and submit our requests regularly. I do not even want to wait until the product is ready to run from our side; at the planning stage, we communicate with the platform to make sure this is doable*."

To elicit this engagement manifestation, platform owners create a playground for complementors to build, explore and experiment, thereby enabling exploratory and innovative use of the platform. P8 reflects on the importance of fostering creativity among complementors: *"[…] to reveal and unleash the real potential of the ecosystem, we believe it is essential to provide playgrounds for developers and incentivize them to play on it. Think of events like hackathons. We give them […] a real problem [with] our platform, and they find solutions to it. We get our solution, okay, but also, they will have a better understanding of the platform and underlying technologies, so, yes, for the future, we can expect them to use this knowledge to come up with creative solutions."* Besides hosting hackathons for selected complementors, platform owners encourage complementors to give feedback through individual PBRs such as emails or personal exchanges to leverage their ideas to improve the platform. To that end, it is essential to be attentive to complementor needs and consider their feedback or technical requests: *"[…] want to leave comments to us regarding the platform. […] we have a dedicated communication line for such requests."* (P8).

4.2.2 Commercializing Products

Product commercialization refers to the activities that complementors engage in to achieve commercial success within the platform ecosystem. They do so by actively reaching out to and interacting with customers and creating brand awareness through marketing efforts, customer service, and strategic differentiation.

Customer Outreach An essential part of being successful as a partner in the ecosystem is to raise awareness of potential customers through marketing activities while simultaneously ensuring the satisfaction of existing customers through attentive customer service. Marketing measures carried out to increase commercial performance include advertising, creating helpful content to capture the interest of the platform's customers, or promotional activities to overcome customers' initial inertia to adopt solutions from relatively unknown complementors. Customer support means responding to customers' needs by effectively handling bad product reviews in the marketplace or offering technical support on product implementation or other issues. C17 highlights the importance of actively engaging with customers as it *"[..] builds a connection with the customer, kind of at a more personal level because they become a part of the product with their feedback."*

To allow complementors to advance their marketing interests within the ecosystem, the platform provides standard PBRs such as prefabricated marketing materials, stock photography, and branding assets. It additionally offers individual PBRs to complementors to position themselves in the ecosystem by enabling direct targeting of customers through ads such as banners, cost-per-click campaigns and featured advertorials or listings on the marketplace, which C14 deems highly effective: *"There was a surprisingly steep increase [i]n our visitors and users after being featured on the app marketplace."* However, besides the resources explicitly provided to facilitate marketing, it is important to note that most platforms do not provide an infrastructure to mediate interactions with customers to aid complementors in supporting customers. C13 explains that they *"[..] have experienced three types of platforms when it comes to how they organize customer support or regulate, whichever term you like. The first type does not let you contact directly, so it is completely indirect; they forward you some emails, you reply to them, and they reply to the customer. The second type has a common area on the platform where users can ask, and vendors can reply. The third type gives complete responsibility to the vendor, not getting involved at all."*

Differentiation Another critical goal of complementors within the platform ecosystem is to differentiate themselves from their competitors, increasing the diversity of offerings on the platform. One way for complementors to set themselves apart from their peers is related to the performance of their software applications. C2 highlights that they compare the performance of their product with the competition through benchmarking because *"[…] competitive tracking is a head start to generate competitive strategies."* Helpful in achieving differentiation according to C15 is to monitor how the market is evolving, customers' current needs, and to what extent these are addressed by the products currently available. Monitoring helps them interpret and navigate the white spaces of the overall platform ecosystem value propositions. C15 emphasizes their engagement "*[…] to generate new strategies, take a different stance on competition, find a new feature and so on."*

As platform owners have a vested interest in the continuous development of the platform's offering and its alignment with customer needs, they share specific data and observations with the ecosystem. To further enable complementors to pursue their commercial interests, they also provide standardized dashboards, which serves as a *"[…]a unified point for tracking their product [with which] they can reply to reviews, monitor their usage statistics, monitor transactions, make changes to non-technical parts of the product and so on. This gives them more control over their product, and it is a self-service pattern, so it is another weight off for us."* Apart from giving complementors the ability to evaluate their products, platform owners seek to stimulate sustainable competition within the ecosystem by sharing insightful data on general usage statistics, market needs, gaps, and competitive analyses. Such standardized PBRs enable complementors to identify new opportunities and strategies and gain a shared understanding of the competitive landscape within the ecosystem. Platform owner P4 points out: *"We try to feed third-party developers with meaningful data periodically, to empower them on innovating new solutions, technologies and letting them know what returns their innovation might bring them."*

4.2.3 Cooperating

Cooperative complementor engagement addresses those activities that leverage the collective power of the ecosystem to drive innovative ideas. Complementors foster the exchange and collective building of knowledge and expertise within the community and actively collaborate with the platform owner to advance the platform.

Community Knowledge Exchange Complementors actively engage in the community by sharing ideas and knowledge with peers in community forums or organized get-togethers such as hackathons, code challenges, or events. Within the community, the exchange among partners is two-sided. While some complementors share best practices or insights regarding platform features or technical development, thus contributing to active knowledge exchange, others benefit from these shared knowledge pools afterward. As such, C1 highlights the value-add of exchanging information with others about platform-specific challenges*: "Searching a query related to a platform on Google is a disappointment most of the time, at least if they do not have a stack exchange. We know the pain. So, yes, these forums are really helpful because it is not just raw support; you also get to know further use cases regarding the technology within the platform."*

Platform owners cultivate a credible and knowledgeable community with standardized PBRs, such as forums, developer blogs, and stack exchanges to exchange know-how and clarify technical issues. Also, platform owners host coding challenges, workshops, hands-on hackathons, and other events as PBRs for selected complementors with the intent of connecting complementors to exchange ideas and share best practices or learnings.

Platform Co-Development One aspect that complementors have frequently taken up is the collaborative development of the platform based on one-to-one exchanges between the platform owner and complementor. Since complements rely heavily on the platform's infrastructure, they also keep track of the platform's health by notifying the platform owner of potential bugs or system glitches. In doing so, complementors *"[…] contribute to the platform indirectly"* (C6). That way, they help to reduce the maintenance efforts of the platform owner by voluntarily investing resources in the cooperative development of the platform. For instance, C3 describes preventing a total platform outage by reporting a *"security flaw"* unrelated to their product, further stating that *"if the platform goes down, everybody goes down. That is how collective initiatives work."*

To encourage such cooperative platform development, platform owners offer dedicated PBRs, including early access programs, through which certain complementors gain insights into the functional or strategic development of the platform. Another distinction is made here between alpha or beta access and the opportunity to vote on important decisions. The purpose of such programs is to strengthen the inclusive platform development process so that complementors gain insights into upcoming updates to prepare for or envision additional features for their products. Platform owner P6 argues that *"[…] without involving complementors in our decision-making processes, developing the platform further is like gambling. So rather than working on assumptions, we have alpha and beta programs in our development process, where we let some of our best complementors have early access. They give feedback, test the platform, and so on, so we have more than assumptions at the end."* Additionally, personal contacts and live chats enable direct communication between complementor and platform owner.

5 Discussion

The current study results provide a detailed understanding of complementor engagement and the role of PBRs in facilitating that engagement. Hence, we reflect the results in light of the recently growing discussion on complementor engagement and complementary strategy (Cenamor, 2021; Saadatmand et al., 2019; Wang and Miller, 2019) and link these findings to the process of distributed tuning of PBRs (Eaton et al., 2015). Furthermore, the study provides additional insights into the use of PBRs by complementors, the design decisions of platform owners to balance scalability via standardization with individual needs of complementors, and links these insights to the multihoming of complementors.

5.1 Complementor Resourcing, Complementor Securing, and the Tuning of Platform Boundary Resources

First, our results show that complementors leverage PBRs to pursue innovation and alignment goals within the platform ecosystem. Similarly, Ghazawneh and Henfridsson (2013) find that PBRs enable resourcing and securing processes for the platform and the platform owner. In this vein, complementor engagement in innovation and alignment with the platform through PBRs represents resourcing and securing processes. Hence, we propose the notion of complementor resourcing and complementor securing.

Complementor resourcing denotes the process by which the innovativeness and commercial success of a complementor's products and services is enhanced. That way, PBRs support complementors to create and sustain competitive advantages through their engagement (Cenamor, 2021). Our study found that platform owners provided PBRs comprising benchmarking tools and market analysis to complementors to support them in their differentiation efforts. We assert that the provision of adequate PBRs represents a viable strategy for platform owners to attract complementors searching for external capabilities to extend their innovation habitat (Selander et al., 2013). At the same time, these PBRs help the platform owner highlight white spaces within the ecosystem and communicate strategic priorities to steer the evolution of the ecosystem towards, for instance, specific market segments (Staykova & Damsgaard, 2017). Complementor engagement with a platform ecosystem to innovate comprises commercialization efforts, enhancing its products, and cooperating with others. Sustaining the various engagements with a single platform can pose a challenge, especially for small or medium-sized complementor organizations. Hence, our findings stress the complexity of employing successful multihoming strategies that complementors carry out and serve to explain the lower-quality performance of multihoming complements observed by prior work (Cennamo et al., 2018). The differences result from the complexity of innovating on several platforms and the challenge of ensuring the alignment and integration with each of them (Claussen et al., 2013; Tanriverdi & Lee, 2008).

In this regard, our results reveal complementors' ongoing resource investments to align with the platform. Hence, *complementor securing* denotes the underlying process by which the complementor's integration and alignment with the platform ecosystem are secured. Complementors ensure the technical alignment with the platform by using PBRs and compliance with legal and regulatory requirements imposed by both legislative entities and the platform owner. The findings shed light on the often-neglected efforts necessary to comply with a vast range of rules and regulations and the transaction costs for complementors through platform governance mechanisms and changes to it. Hence, platform owners are confronted with supporting changes in governance so complementors can sustain the performance of their applications (Hurni et al., 2020; R. Kapoor & Agarwal, 2017). In addition to individual PBRs such as personal contacts, standardized PBRs, such as documentation and town halls, can support successful transitions. Nevertheless, from an entrepreneurial perspective, the additional effort to comply with the platform's rules (besides market-wide legislation) may inhibit entrepreneurial activity within particular platform ecosystems (Nambisan, 2017; Nambisan et al., 2018).

These insights emphasize that platform owners and complementors are challenged to balance resourcing and securing processes. In essence, complementor engagement reflects the tension to innovate while ensuring alignment with the platform. Additionally, by introducing complementor resourcing and securing resulting from complementors' engagement with and through PBRs, we provide a complementary perspective on the ongoing process of distributed tuning of PBRs (Eaton et al., 2015) and provide additional insights on the genesis of boundary objects (Bharosa et al., 2012). In that sense, distributed tuning of PBRs is the observable interplay and result of complementors' resourcing and securing activities and the platform owner's resourcing and securing activities (Ghazawneh & Henfridsson, 2013). Therefore, the current study takes another step toward a more balanced perspective on digital platform ecosystems and mitigates the myopic focus of prior work on platform owners (Cenamor, 2021; Tavalaei & Cennamo, 2020).

5.2 The Role of Uniform and Individual Platform Boundary Resources

Second, platform owners provide PBRs to stimulate complementor engagement and value cocreation. Hein et al. (2019c) note that the standardization of PBRs across the ecosystem acts as a significant driver for the scalability of the ecosystem, while residual mechanisms support individual innovation paths outside these standardized processes. Our findings underline this dualistic role of PBRs by distinguishing between uniform (i.e., standardized) and individual (i.e., residual) PBRs. According to our results, uniform PBRs (e.g., benchmarking tools, general agreements) enable all five engagement types and are standardized for all complementors. This allows the platform to support and enable the underlying engagement regardless of the size of the ecosystem, thus maintaining loose coupling. At the same time, individual PBRs (e.g., email, live chats, or personal contacts) foster engagement for selected, closely coupled complementors and are less prominent in our study than standardized ones. Moreover, both uniform and individual PBRs affect the engagement of complementors in the contexts of innovation, governance, and communication with the platform owner.

On the one hand, these findings have implications for platform owners facing the challenge of standardizing their PBRs for all complementors while providing dedicated support to individual complementors to increase local value cocreation (Huber et al., 2017). This tension is reflected in the provision of uniform and individual PBRs. Partner programs assign partners to certain levels and help prioritize interactions between the platform and its complementors transparently and according to specific key performance indicators (KPIs) (Engert et al., 2020). Similar to bending governance rules for some complementors as proposed by Huber et al. (2017), PBRs allow the platform to scale while maintaining control via standardized PBRs and addressing needs with individual PBRs to foster local innovation.

On the other hand, we see high levels of complementor multihoming in our research setting. Hence, the challenge for platform owners increases to allow complementors easy, self-service onboarding and engagement, which is enabled by standardized PBR, keeping entry barriers low for complementors. Individual PBRs then serve to address platform specifics or concrete issues faced by complementors on-demand, which is reflected in our findings. From an industry perspective, it is to be expected that standardized PBRs are similar across CMS platforms in the industry, following a dominant design (Anderson & Tushman, 1990). Since the differences in characteristics of PBRs across platforms generally is not within the scope of our study, we encourage future work to compare PBRs across platforms in highly competitive industries with intense multihoming of complementors and investigate dominant PBR designs within industries. Also, it is worthwhile to investigate the role of individual PBRs in differentiating platforms in the same industries, potentially contributing to research on interplatform competition (Cennamo & Santalo, 2013; Dubé et al., 2010).

5.3 Limitations and Future Work

The study faces several limitations. First, the findings might not be transferable to other industries since it focuses on e-commerce CMS platforms. Future work can examine different industries in the business-to-business domain, such as enterprise resource planning (ERP) software platforms, to increase the generalizability of the findings (Yin, 2018). Second, the qualitative data underlying the findings can only indicate the relations between complementor engagement and the use of PBRs. One opportunity for future work may build on the proposed relations and investigate specific PBRs, such as APIs and their detailed use by complementors based on monitoring API calls. The open-source setting of WordPress may provide the accessibility necessary for researchers to conduct this type of study.

6 Conclusion

The current study investigates complementor engagement within digital platform ecosystems and the role of PBRs in supporting and enabling this engagement. Applying a two-step research approach, we first conduct interviews with representatives of nine e-commerce CMS platforms and then focus on analyzing three e-commerce CMS platforms, interviewing 15 representatives of complementor organizations. We chose WordPress, Magento, and Shopify as units of analysis within the e-commerce CMS platform context. From the data, we inductively create a detailed understanding of five types of complementor engagement, which are associated with two engagement goals. Each engagement type comprises two manifestations, with each manifestation utilizing different PBRs. We distinguish between uniform and individual PBRs to differentiate them according to their generalizability and scalability.

The current paper thus advances the understanding of complementor engagement and its relations with uniform and individualized PBRs. Introducing the novel concepts of complementor resourcing and complementor securing, we emphasize the original notion of PBRs enabling resourcing and securing processes (Ghazawneh & Henfridsson, 2013). Moreover, we clarify the standardization-individualization tension concerning the provision of PBRs for platform owners and bring forward the idea of dominant PBR designs within highly competitive platform industries. The integrated perspective on PBRs and their role in engaging complementors allows practitioners to make informed decisions concerning strategic PBR design. Managers on the complementor side benefit from systemizing their engagement activities to develop competitive strategies around PBRs.

Appendix 1 Characteristics of all platforms in the first interview round

Table 6 Characteristics of all platforms in the first interview round

Interviewee	*Size of App Store**	*Open Source vs. Proprietary*
Platform 1	small	Proprietary
Platform 2	small	Proprietary
Platform 3	large	Open Source
Platform 4	small	Proprietary
Platform 5	medium	Proprietary
Platform 6	medium	Open Source
Platform 7	large	Proprietary
Platform 8	large	Open Source
Platform 9	large	Open Source

**small [50–500 apps]; medium [501–3000 apps]; large [3001 + apps]*

Appendix 2 Overview of interview guidelines

Table 7 Overview of interview guidelines

Interview guideline – platform owners

- Information about company and interviewee
- Part 1: Questions regarding ecosystem orchestration strategy of the platform, expectation management, preliminary enablement of the complementors, and process of shipping complementary products to the marketplace
- Part 2: Questions regarding reviewing complimentary products, initiating maintenance processes, conflict resolution, community orchestration, communication channels with complementors, and igniting innovation
- Part 3: Questions regarding benchmarking complementors, ecosystem governance strategies, enforcing requirements, and business level interactions

Interview guideline– complementors

- Information about company and interviewee
- Part 1: Questions regarding digital platform selection, expectations from digital platforms, preliminary engagement with the platforms, and process of building complementary products for digital platforms
- Part 2: Questions regarding platform engagement on maintenance processes of complementary products, conflicts, bugs within the platform, participation in the community, interactions with the platform, and innovation
- Part 3: Questions regarding evaluating performance, competition strategies, compliance with platform requirements, and business level interactions

Appendix 3 Engagement manifestations and associated PBRs

Table 8 Engagement manifestations and associated PBRs

Engagement Types	*Engagement Manifestations*	*Uniform PBRs (one-to-many)*	*Individual PBRs (one-to-one or one-to-few)*
Developing Products	Technical Integration	API, SDK (debuggers, compilers), sandboxes, testing environments, documentation, guidelines, tutorials, videos, training, webinars	Exclusive training
	Technical Requirements	Code quality standards, design specifications, blogs, documentation, (code and style) reviews	-
Ensuring Compliance	Legal Compliance	Terms and conditions agreements, protection of proprietary rights, privacy policies	-
	Regulatory Compliance	Agreements, clarifications of property rights, privacy policies, conflict resolution procedures and enforcement procedures, accounting system for payment processing, transaction management, and financial reporting standards	-
Enhancing Products	Troubleshooting	Testing tools, debugging tools, newsletters, guidelines, documentation, changelogs, monthly town halls, forums, stack exchange	Personal contacts, live chats, emails, phone contacts
	Technical Requests	-	Hackathons, emails, personal contacts
Commercializing Products	Marketing	Prefabricated marketing materials, stock photography, and branding assets	Workshops, listings on the marketplace, advertorials, ads such ad banners, cost-per-click campaigns, featured blog postings
	Competitive Differentiation	Benchmarking tools, interfaces to configure non-technical product aspects, market intelligence, and platform ecosystem briefings	-
Cooperating	Knowledge Exchange	Blogs, forums, stack exchange	Hackathons, code challenges, events, workshops
	Platform Co-Development	-	Personal contacts, live chats, emails, phone contacts, Early access programs (alpha and beta)

Acknowledgments The authors would like to thank Bugra Cil for his support in data collection and analysis.

Funding Open Access funding enabled and organized by Projekt DEAL.

Declarations

Conflict of interest The authors declare that they have no conflict of interest.

References

Adner, R. (2017). Ecosystem as Structure: An Actionable Construct for Strategy. *Journal of Management, 43*(1), 39–58. https://doi.org/10.1177/0149206316678451

Anderson, P., & Tushman, M. L. (1990). Technological Discontinuities and Dominant Designs: A Cyclical Model of Technological Change. *Administrative Science Quarterly, 35*(4), 604. https://doi.org/10.2307/2393511

Armstrong, M. (2006). Competition in two-sided markets. *The RAND Journal of Economics, 37*(3), 668–691. https://doi.org/10.1111/j.1756-2171.2006.tb00037.x

Bharosa, N., Lee, J., Janssen, M., & Rao, H. R. (2012). An activity theory analysis of boundary objects in cross-border information systems development for disaster management. *Security Informatics*, *1*(1). https://doi.org/10.1186/2190-8532-1-15

Bianco, V. D., Myllarniemi, V., Komssi, M., & Raatikainen, M. (2014). The Role of Platform Boundary Resources in Software Ecosystems: A Case Study. *IEEE/IFIP Conference on Software Architecture*, 11–20. https://doi.org/10.1109/WICSA.2014.41

Boudreau, K. J. (2010). Open platform strategies and innovation: Granting access vs. devolving control. *Management Science, 56*(10), 1849–1872. https://doi.org/10.1287/mnsc.1100.1215

Boudreau, K. J. (2012). Let a thousand flowers bloom? An early look at large numbers of software app developers and patterns of innovation. *Organization Science, 23*(5), 1409–1427. https://doi.org/10.1287/orsc.1110.0678

Ceccagnoli, M., Forman, C., Huang, P., & Wu, D. J. (2012). Cocreation of Value in a Platform Ecosystem: The Case of Enterprise Software. *MIS Quarterly, 36*(1), 263–290. https://doi.org/10.2307/41410417

Cenamor, J. (2021). Complementor competitive advantage: A framework for strategic decisions. *Journal of Business Research, 122*, 335–343. https://doi.org/10.1016/j.jbusres.2020.09.016

Cennamo, C., Ozalp, H., & Kretschmer, T. (2018). Platform architecture and quality trade-offs of multihoming complements. *Information Systems Research, 29*(2), 461–478. https://doi.org/10.1287/isre.2018.0779

Cennamo, C., & Santalo, J. (2013). Platform competition: Strategic trade-offs in platform markets. *Strategic Management Journal, 34*(11), 1331–1350. https://doi.org/10.1002/smj.2066

Cennamo, C., & Santalo, J. (2019). Generativity Tension and Value Creation in Platform Ecosystems. *Organization Science, 30*(3), 617–641. https://doi.org/10.1287/orsc.2018.1270

Claussen, J., Kretschmer, T., & Mayrhofer, P. (2013). The effects of rewarding user engagement: The case of Facebook apps. *Information Systems Research, 24*(1), 186–200. https://doi.org/10.1287/isre.1120.0467

Constantinides, P., Henfridsson, O., & Parker, G. G. (2018). Platforms and Infrastructures in the Digital Age. *Information Systems Research, 29*(2), 381–400. https://doi.org/10.1287/isre.2018.0794

Cusumano, M. A., Yoffie, D. B., & Gawer, A. (2020). The Future of Platforms. *MIT Sloan Management Review*. Retrieved from https://sloanreview.mit.edu/article/the-future-of-platforms/

De Reuver, M., Sørensen, C., & Basole, R. C. (2018). The Digital Platform: A Research Agenda. *Journal of Information Technology, 33*(2), 124–135. https://doi.org/10.1057/s41265-016-0033-3

de Lima Fontão, A., dos Santos, R. P., & Dias-Neto, A. C. (2019). Exploiting Repositories in Mobile Software Ecosystems from a Governance Perspective. *Information Systems Frontiers, 21*(1), 143–161. https://doi.org/10.1007/s10796-018-9861-8

Drucker, P. F. (2003). *The new realities* (New). Transaction Publ.

Dubé, J.-P.H., Hitsch, G. J., & Chintagunta, P. K. (2010). Tipping and Concentration in Markets with Indirect Network Effects. *Marketing Science, 29*(2), 216–249. https://doi.org/10.1287/mksc.1090.0541

Eaton, B., Elaluf-Calderwood, S., Sørensen, C., & Yoo, Y. (2015). Distributed tuning of boundary resources: The case of Apple's iOS service system. *MIS Quarterly, 39*(1), 217–243. https://doi.org/10.25300/misq/2015/39.1.10

Eisenhardt, K. M. (1989). Building Theories from Case Study Research. *The Academy of Management Review, 14*(4), 532–550. https://doi.org/10.2307/258557

Engert, M., Chu, Y., Hein, A., & Krcmar, H. (2021). Managing the Interpretive Flexibility of Technology: A Case Study of Celonis and its Partner Ecosystem. In *Forty-Second International Conference on Information Systems: ICIS 2021,* Austin, TX, United States of America

Engert, M., Hein, A., & Krcmar, H. (2020). Partner Programs and Complementor Assessment in Platform Ecosystems: A Multiple-Case Study. In *Twenty-Sixth Americas Conference on Information Systems: AMCIS 2020,* A Virtual Conference (Due to global COVID-19 situation)

Engert, M., Pfaff, M., & Krcmar, H. (2019). Adoption of Software Platforms: Reviewing Influencing Factors and Outlining Future Research. In *Twenty-Third Pacific Asia Conference on Information Systems: PACIS 2019,* Xi'An, China

Floetgen, R. J., Strauss, J., Weking, J., Hein, A., Urmetzer, F., Böhm, M., & Krcmar, H. (2021). Introducing platform ecosystem resilience: leveraging mobility platforms and their ecosystems for the new normal during COVID-19. *European Journal of Information Systems*, 1–18. https://doi.org/10.1080/0960085X.2021.1884009

Foerderer, J., Kude, T., Schuetz, S. W., & Heinzl, A. (2019). Knowledge boundaries in enterprise software platform development: Antecedents and consequences for platform governance. *Information Systems Journal, 29*(1), 119–144. https://doi.org/10.1111/isj.12186

Ghazawneh, A., & Henfridsson, O. (2010). Governing third-party development through platform boundary resources. In *Thirty-First International Conference on Information Systems: ICIS 2010,* St. Louis, MO, United States of America

Ghazawneh, A., & Henfridsson, O. (2011). Micro-Strategizing in Platform Ecosystems: A Multiple Case Study. In *Thirty-Second International Conference on Information Systems: ICIS 2011,* Shanghai, China

Ghazawneh, A., & Henfridsson, O. (2013). Balancing platform control and external contribution in third-party development: The boundary resources model. *Information Systems Journal, 23*(2), 173–192. https://doi.org/10.1111/j.1365-2575.2012.00406.x

Ghazawneh, A., & Henfridsson, O. (2015). A paradigmatic analysis of digital application marketplaces. *Journal of Information Technology, 30*(3), 198–208. https://doi.org/10.1057/jit.2015.16

Glaser, B. G., & Strauss, A. L. (1967). *The discovery of grounded theory: Strategies for qualitative research*. Aldine.

Grzenda, M., & Legierski, J. (2021). Towards Increased Understanding of Open Data Use for Software Development. *Information Systems Frontiers, 23*(2), 495–513. https://doi.org/10.1007/s10796-019-09954-6

Harvey, M. G., & Lusch, R. F. (1995). A systematic assessment of potential international strategic alliance partners. *International Business Review, 4*(2), 195–212. https://doi.org/10.1016/0969-5931(95)00005-K

Hein, A., Schreieck, M., Riasanow, T., Setzke, D. S., Wiesche, M., Böhm, M., & Krcmar, H. (2019a). Digital platform ecosystems. *Electronic Markets, 30*(1), 87–98. https://doi.org/10.1007/s12525-019-00377-4

Hein, A., Schreieck, M., Wiesche, M., Böhm, M., & Krcmar, H. (2019b). The emergence of native multi-sided platforms and their influence on incumbents. *Electronic Markets, 29*(4), 631–647. https://doi.org/10.1007/s12525-019-00350-1

Hein, A., Weking, J., Schreieck, M., Wiesche, M., Böhm, M., & Krcmar, H. (2019c). Value co-creation practices in business-to-business platform ecosystems. *Electronic Markets, 29*(3), 503–518. https://doi.org/10.1007/s12525-019-00337-y

Helfat, C. E., & Raubitschek, R. S. (2018). Dynamic and integrative capabilities for profiting from innovation in digital platform-based ecosystems. *Research Policy, 47*(8), 1391–1399. https://doi.org/10.1016/j.respol.2018.01.019

Huber, T. L., Kude, T., & Dibbern, J. (2017). Governance practices in platform ecosystems: Navigating tensions between cocreated value and governance costs. *Information Systems Research, 28*(3), 563–584. https://doi.org/10.1287/isre.2017.0701

Hurni, T., Huber, T. L., Dibbern, J., & Krancher, O. (2020). Complementor dedication in platform ecosystems: rule adequacy and the moderating role of flexible and benevolent practices. *European Journal of Information Systems*, 1–24. https://doi.org/10.1080/0960085X.2020.1779621

Jacobides, M. G., Cennamo, C., & Gawer, A. (2018). Towards a theory of ecosystems. *Strategic Management Journal, 39*(8), 2255–2276. https://doi.org/10.1002/smj.2904

Kannisto, P., Hästbacka, D., & Marttinen, A. (2020). Information Exchange Architecture for Collaborative Industrial Ecosystem. *Information Systems Frontiers, 22*(3), 655–670. https://doi.org/10.1007/s10796-018-9877-0

Kapoor, K., Ziaee Bigdeli, A., Dwivedi, Y. K., Schroeder, A., Beltagui, A., & Baines, T. (2021). A socio-technical view of platform ecosystems: Systematic review and research agenda. *Journal of Business Research, 128*, 94–108. https://doi.org/10.1016/j.jbusres.2021.01.060

Kapoor, R., & Agarwal, S. (2017). Sustaining superior performance in business ecosystems: Evidence from application software developers in the iOS and android smartphone ecosystems. *Organization Science, 28*(3), 531–551. https://doi.org/10.1287/orsc.2017.1122

Karhu, K., Gustafsson, R., & Lyytinen, K. (2018). Exploiting and Defending Open Digital Platforms with Boundary Resources: Android's Five Platform Forks. *Information Systems Research, 29*(2), 479–497. https://doi.org/10.1287/isre.2018.0786

Koch, S., & Kerschbaum, M. (2014). Joining a smartphone ecosystem: Application developers' motivations and decision criteria. *Information and Software Technology, 56*(11), 1423–1435. https://doi.org/10.1016/j.infsof.2014.03.010

Kude, T., Dibbern, J., & Heinzl, A. (2012). Why do complementors participate an analysis of partnership networks in the enterprise software industry. *IEEE Transactions on Engineering Management, 59*(2), 250–265. https://doi.org/10.1109/TEM.2011.2111421

Lusch, R. F., & Nambisan, S. (2015). Service Innovation: A Service-Dominant Logic Perspective. *MIS Quarterly, 39*(1), 155–175. https://doi.org/10.25300/MISQ/2015/39.1.07

Nambisan, S. (2017). Digital Entrepreneurship: Toward a Digital Technology Perspective of Entrepreneurship. *Entrepreneurship Theory and Practice, 41*(6), 1029–1055. https://doi.org/10.1111/etap.12254

Nambisan, S., Siegel, D., & Kenney, M. (2018). On open innovation, platforms, and entrepreneurship. *Strategic Entrepreneurship Journal, 12*(3), 354–368. https://doi.org/10.1002/sej.1300

Parker, G. G., van Alstyne, M. W., & Jiang, X. (2017). Platform ecosystems: How developers invert the firm. *MIS Quarterly, 41*(1), 255–266.

Petrik, D., & Herzwurm, G. (2020a). Boundary Resources for IIoT Platforms - a Complementor Satisfaction Study. In *Forty-First International Conference on Information Systems: ICIS 2020,* A digital conference (due to Covid-19)

Petrik, D., & Herzwurm, G. (2020b). Towards the IIoT Ecosystem Development - Understanding the Stakeholder Perspective. In *Twenty-Eighth European Conference on Information Systems: ECIS 2020,* A Digital Conference

Rickmann, T., Wenzel, S., & Fischbach, K. (2014). Software Ecosystem Orchestration: The Perspective of Complementors. In *Twentieth Americas Conference on Information Systems: AMCIS 2014,* Savannah, GA, United States of America.

Saadatmand, F., Lindgren, R., & Schultze, U. (2019). Configurations of platform organizations: Implications for complementor engagement. *Research Policy, 48*(8), 103770. https://doi.org/10.1016/j.respol.2019.03.015

Schreieck, M., Wiesche, M., & Krcmar, H. (2021). Capabilities for Value Co-Creation and Value Capture in Emergent Platform Ecosystems: A Longitudinal Case Study of SAP's Cloud Platform. *Journal of Information Technology.* Advance online publication. https://doi.org/10.1177/02683962211023780

Schulz, T., Gewald, H., Böhm, M., & Krcmar, H. (2020). Smart Mobility: Contradictions in Value Co-Creation. *Information Systems Frontiers.* Advance online publication. https://doi.org/10.1007/s10796-020-10055-y

Selander, L., Henfridsson, O., & Svahn, F. (2013). Capability search and redeem across digital ecosystems. *Journal of Information Technology, 28*(3), 183–197. https://doi.org/10.1057/jit.2013.14

Soto Setzke, D., Riasanow, T., Böhm, M., & Krcmar, H. (2021). Pathways to Digital Service Innovation: The Role of Digital Transformation Strategies in Established Organizations. *Information Systems Frontiers.* Advance online publication. https://doi.org/10.1007/s10796-021-10112-0

Star, S. L. (2010). This is Not a Boundary Object: Reflections on the Origin of a Concept. *Science, Technology, & Human Values, 35*(5), 601–617. https://doi.org/10.1177/0162243910377624

Staykova, K. S., & Damsgaard, J. (2017). Towards an Integrated View of Multi-Sided Platforms Evolution. *International Conference on Information Systems (ICIS)*

Tanriverdi, H., & Lee, C.-H. (2008). Within-industry diversification and firm performance in the presence of network externalities: Evidence from the software industry. *Academy of Management*

Journal, 51(2), 381–397. https://doi.org/10.5465/AMJ.2008.31767300
Tavalaei, M. M., & Cennamo, C. (2020). In search of complementarities within and across platform ecosystems: Complementors' relative standing and performance in mobile apps ecosystems. *Long Range Planning*, 101994. https://doi.org/10.1016/j.lrp.2020.101994
Tiwana, A. (2014). *Platform ecosystems: Aligning architecture, governance, and strategy*. Amsterdam et al., Netherlands et al.: Morgan Kaufmann
Tiwana, A. (2015). Platform desertion by app developers. *Journal of Management Information Systems, 32*(4), 40–77. https://doi.org/10.1080/07421222.2015.1138365
Tiwana, A., Konsynski, B., & Bush, A. A. (2010). Platform evolution: Coevolution of platform architecture, governance, and environmental dynamics. *Information Systems Research, 21*(4), 675–687. https://doi.org/10.1287/isre.1100.0323
W3Techs. (2021). Usage statistics of content management systems. Retrieved from https://w3techs.com/technologies/overview/content_management
Wan, X., Cenamor, J., Parker, G. G., & van Alstyne, M. W. (2017). Unraveling platform strategies: A review from an organizational ambidexterity perspective. *Sustainability, 9*(5), 734–752. https://doi.org/10.3390/su9050734
Wang, R. D., & Miller, C. D. (2019). Complementors' engagement in an ecosystem: A study of publishers' e-book offerings on Amazon Kindle. *Strategic Management Journal, 76*(3), 70. https://doi.org/10.1002/smj.3076
Wang, S., Zheng, S., Xu, L., Li, D., & Meng, H. (2008). A literature review of electronic marketplace research: Themes, theories and an integrative framework. *Information Systems Frontiers, 10*(5), 555–571. https://doi.org/10.1007/s10796-008-9115-2
Wareham, J., Fox, P. B., & Giner, J. (2014). Technology ecosystem governance. *Organization Science, 25*(4), 1195–1215. https://doi.org/10.1287/orsc.2014.0895
Yin, R. K. (2018). *Case study research and applications: Design and methods* (6th ed.). SAGE.
Yu, Y., & Ramaprasad, J. (2019). Engagement on Digital Platforms: A Theoretical Perspective. In *Fortieth International Conference on Information Systems: ICIS 2019,* Munich, Germany
Zhang, J., Li, S., & Wang, Y. (2021). Shaping a Smart Transportation System for Sustainable Value Co-Creation. *Information Systems Frontiers.* Advance online publication. https://doi.org/10.1007/s10796-021-10139-3

Martin Engert is a Ph.D. student at the Chair for Information Systems at the Technical University of Munich (TUM), Munich, Germany. He holds a Master's degree in Management at TUM. Martin has experience in innovation and intellectual property (IP) management from AUDI AG and ZF Friedrichshafen AG. Besides, he worked as an IP consultant. His research interests concern digital platform ecosystems, value co-creation, open-data, and data-driven business models. His work was published in conference proceedings such as ICIS, AMCIS, and PACIS.

Julia Evers is a graduate student in the interdisciplinary study program Management and Technology at the Technical University of Munich (TUM), Munich, Germany. She has pursued her interest in digital technologies and their impact on the business world both professionally and academically. In projects at Airbus or Celonis, she gained practical experience assessing the transformation potential of blockchain or process mining. In her academic education, she gained a deep understanding of complementor engagement in digital platform ecosystems.

Andreas Hein is a research group leader at the Chair for Information Systems, Technical University of Munich (TUM), Munich, Germany. He holds a Master's degree at TUM in Information Systems. In addition, Andreas has three years of experience as a Senior Strategy Consultant at IBM. His work has appeared in journals such as the European Journal of Information Systems, Business & Information Systems Engineering, and Electronic Markets and refereed conference proceedings such as ICIS, ECIS, PACIS, AMCIS, and HICSS. Andreas focuses his research on digital platform ecosystems, distributed ledger technologies, and value co-creation in complex ecosystems.

Helmut Krcmar is Professor Emeritus of Information Systems with the Department of Informatics, Technische Universität München (TUM), Munich, Germany, with a joint appointment with the School of Management, where he is currently the Founding Dean and Delegate Officer of the President – TUM Campus Heilbronn. He has been a Postdoctoral Fellow with IBM Los Angeles Scientific Center, and an Assistant Professor of Information Systems with the Leonard Stern School of Business, NYU, and Baruch College, CUNY. From 1987 to 2002, he was the Chair of Information Systems, Hohenheim University, Stuttgart, where he was the Dean of the Faculty of Business, Economics and Social Sciences. From 2002 to 2020, he was the Chair of Information Systems with the Department of Informatics, TUM, where he was the Dean from 2010 to 2013. His research interests include information and knowledge management, engineering, piloting, and management of innovative IT-based services, computer support for collaboration in distributed and mobile work and learning processes. Interdisciplinary work incorporates areas such as accounting, mechanical engineering, and health care. He has coauthored a plethora of research papers published in major IS journals, including MISQ, JMIS, JIT, ISJ, JSIS, EJIS, and IEEE Transactions on Engineering Management. Helmut Krcmar is a Fellow of the Association for Information Systems (AIS) and a Member of Acatech National Academy of Science and Engineering.

Appendix C. (P3) Managing the Interpretive Flexibility of Technology: A Case Study of Celonis and its Partner Ecosystem

Managing the Interpretive Flexibility of Technology: A Case Study of Celonis and its Partner Ecosystem

Short Paper

Martin Engert
Technical University of Munich
Boltzmannstrasse 3
85748 Garching, Germany
martin.engert@tum.de

Yifang Chu
Celonis SE
Theresienstrasse 6
80333 Munich, Germany
y.chu@celonis.com

Andreas Hein
Technical University of Munich
Boltzmannstrasse 3
85748 Garching, Germany
andreas.hein@tum.de

Helmut Krcmar
Technical University of Munich
Boltzmannstrasse 3
85748 Garching, Germany
helmut.krcmar@tum.de

Abstract

IT artifacts as embodiments of digital technologies are perceived differently by different user groups – a characteristic denoted as the technology's interpretive flexibility. As emphasized in prior contributions, social and technological factors shape the different outcomes of the focal technology. What is less clear is how technology firms can manage and exploit the interpretive flexibility of their technology to maximize their value potential while adequately addressing their (potential) customers' needs. This ongoing study aims to investigate the mechanisms technology providers use to strike that balance individually and collectively. Between 2018 and 2021, we conduct an in-depth case study of Celonis the market leader in process mining, and develop a preliminary model for managing the interpretive flexibility of technology. Focusing on Celonis' efforts to create a partner ecosystem around its core technology, we find two basic mechanisms through which partners increase (deployment) or decrease (abstraction) the interpretive flexibility of Celonis' technology.

Keywords: interpretive flexibility; boundary management; process mining; digital platform ecosystem; partner ecosystem

Introduction

Researchers have long discussed the role of technology in organizations and the interplay between social and technological aspects in influencing organizational outcomes (Orlikowski 1992; Sahay and Robey 1996). The *interpretive flexibility* (Pinch and Bijker 1984) of technology follows the academic discourse on the social construction of technology (SCOT), and the characteristic is open to more than one interpretation. The concept helps explain how the implementation of the same technology can lead to different (organizational) outcomes (Doherty et al. 2006). For instance, machine learning (ML) technology exhibits great interpretive flexibility because different groups of users (e.g., experienced vs. inexperienced users) perceive the characteristics, expectations, and limitations of the technology in different ways and, thus, shape the outcomes of its application (Harandi et al. 2020). The differences in outcomes lie in social and technological factors that influence the shape of the technology (Cadili and Whitley 2005; Orlikowski 1992).

Compared to other (i.e., non-digital) technologies, IT artifacts (as embodiments of digital technologies) are particularly flexible. Machine learning platforms, e-government portals, or basic tools such as Microsoft Excel, for example, are highly adaptable to users' needs and inputs. This emphasizes the influence of technological properties on a technology's interpretive flexibility as perceived by users (Chen et al. 2009; Doherty et al. 2006). This situation yields opportunities and challenges for providers of IT artifacts because they may adapt the artifact to their particular user groups. This results in lower interpretive flexibility and increased value to users (Jensen and Aanestad 2007).

At the same time, by adapting the IT artifact, providers can prevent its usefulness to other user groups, which lowers the potential economic value associated with the technology. For instance, a provider of an ERP (Enterprise Resource Planning) system, may choose to adjust its technology to the needs of large enterprises in the pharmaceutical industry. While this particular customer group will receive great value from the product's specific features, other customer groups like small-and-medium-sized firms in the construction industry will gain less value from this ERP system. Hence, technology providers need to precisely balance the interpretive flexibility of their technology to the needs of their customers (i.e., to increase customer value through low interpretive flexibility), while expanding their potential market (i.e., increase the technology provider's value through high interpretive flexibility).

In recent years, process mining has been one of the most promising digital technologies in the business domain (Kerremans 2019; van der Aalst 2016). Big Data Analysis (BDA) technology builds on the analysis of event logs in information systems to analyze the actual execution of business processes on the system, while being agnostic to the source system (Eggers and Hein 2020; Geyer-Klingenberg et al. 2018). Process mining is used to discover actual process instances, monitor real-time process flows, and improve business process design based on the analysis (van der Aalst 2011). Latest developments in the field have focused not only on the passive analysis of past process data but proactive process execution based on live monitoring, situational context, and decision models (e.g., Kerremans (2019)). Unsurprisingly, the technology has spurred great demand among organizations to improve processes and adapt to steadily changing business requirements (Altinkemer et al. 2011; Kerremans 2019). Users access and use the technology via software firms such as Celonis, the market leader in process mining (Kerremans 2019), which provides the technology as a highly configurable Software as a Service (SaaS). Process mining has been applied in various industries and organizational contexts, for different types of processes, on different IT systems, data types, and for various purposes (Eggers and Hein 2020).

Siemens was one of Celonis' first customers in 2011 and faced a decision on which processes to start analyzing with process mining. Without an upfront analysis, it was uncertain which of Siemens' many business processes held the most significant automation potential, given that almost any process comprising event logs would be feasible to analyze with Celonis' process mining technology. Finally, both companies decided to apply Celonis' early technology in Siemens' accounting department. This laid the foundation for Celonis' expertise in accounting processes such as accounts payable (Reinkemeyer 2020). This example illustrated that process mining technology exhibits great interpretive flexibility for both Celonis and its customers. Customers need to decide which process to analyze, while firms such as Celonis must decide on the process analysis and related support and the necessary consulting expertise to bring to the market.

Consequently, companies such as Celonis invest considerable resources to manage and exploit their focal technology's interpretive flexibility and provide valuable and readily applicable solutions to its (potential) users and partners. For instance, prior research suggests that during the design of the technology itself and through the creation and continuous adjustment of its functional boundaries, a technology's interpretive flexibility for users can be pre-defined in the technological domain (Doherty et al. 2006; Orlikowski 1992): The fictional ERP provider could shape its technology's functional boundaries by fixating the available fields in its ERP software to suit the pharmaceutical industry. This involves striking the balance between too harsh restrictions (i.e., low interpretive flexibility), that limit its potential market and too wide restrictions (i.e., high interpretive flexibility) that increase ambiguity for customers.

However, how organizations individually and collectively identify, set, and adjust a focal technology's interpretive flexibility remains unexplored. Moreover, how they may manage and exploit the resulting functionality space to attract new customers while mitigating the ambiguity that results from having too many options available, has been outside the focus of prior work. Thus, our study is guided by the following research question:

RQ: How do organizations manage and exploit the interpretive flexibility of their technology?

To answer this question, we conduct a longitudinal case study of Celonis' journey from a process mining startup towards a unicorn-status software platform company between 2018 and 2021. We do so by building on the theoretical lens of interpretive flexibility and the perspective of digital platform ecosystems as the organizational setup. By witnessing and analyzing the interplay of social and technical dimensions when shaping and managing the interpretive flexibility of process mining technology, this ongoing research effort can be located at the core of IS research belonging to the Type IV category according to Sarker et al. (2019).

As part of an ongoing research effort, we inductively analyze the data and preliminarily find that during the time of our study, Celonis traversed different episodes in which it iteratively established an ecosystem of partners to accelerate the deployment of its process mining technology, resulting in Celonis non-linear growth. Hence, we closely observe the interactions between Celonis, its partners, and customers, which manifest in the continuous adjustments to Celonis organizational design and the underlying interpretive flexibility. Iteratively, Celonis managed to make process mining more accessible to its (potential) customers, thus democratizing the access to the technology through the lens of interpretive flexibility. Based on our insights we present a preliminary model for managing the interpretive flexibility of technology.

For future research work, we plan to conduct further interviews to refine and recalibrate our findings and enrich the insights on the changes of Celonis' partner ecosystem and extend our longitudinal dataset. Particularly, we want to include the latest episode starting in late 2020, when Celonis announced to establish the world's first Execution Management System (EMS), allowing customers to automate and optimize business process execution enabled by its process mining core.

Conceptual Foundation

Interpretive Flexibility of Technology

Interpretive flexibility denotes a focal technology's characteristic of being open to more than one interpretation (Pinch and Bijker 1984). According to Pinch and Bijker (1984), a technology's interpretive flexibility eventually enters the stages of *closure* and *stabilization*, where all actors within a relevant social group converge in their interpretation of the focal technology and its meaning, features, and purpose. However, IS researchers have argued that closure in the context of IT, is unlikely to occur. and that there may be different interpretations of one technology (Doherty et al. 2006; Sahay and Robey 1996). An IT artifact such as Google's Android platform continues to evolve based on the underlying technology and its many different areas of application, which range from smartphones to smart TVs and cars. Hence, we follow the definition of Sahay and Robey (1996, p. 260), stating that interpretive flexibility is *"the capacity of a specific technology to sustain divergent opinions."* Early studies investigated interpretive flexibility in different contexts and with different underlying IT systems that ranged from Geographic Information Systems (GIS) in government agencies (Sahay and Robey 1996), and ERP-systems in a large multinational (Cadili and Whitley 2005) to Electronic Patient Records (EPR) in hospitals (Jensen and Aanestad 2007). These studies focused primarily on the differences in outcomes when the same technology is implemented in different organizations or organizational subunits. Thus, the role of the social dimension and the importance of involving users was emphasized. However, differences in interpretive flexibility are not only influenced by the social dimension (i.e., the actors involved and the context in which the technology is used) but also by the underlying properties of the focal technology. This is the case of IT artifacts as embodiments of digital technologies (Doherty et al. 2006; Orlikowski 1992). According to Orlikowski (1992), the interpretive flexibility of technology is a result of human interaction in the *design mode* and *use mode* of the technology. Hence, designers, such as software engineers of IT firms influence a focal technology's interpretive flexibility as perceived by users. Accordingly, the design mode allows firms to manage interpretive flexibility by design.

Under high interpretive flexibility, potential users of a technology face great uncertainty. They have problems in understanding the purpose and potential of the technology, its use cases, and the actual use (Cadili and Whitley 2005; Orlikowski 1992). This uncertainty manifests in either rejection or unintended usage of the focal technology. However, it also grants users the freedom to apply the technology more flexibly (Orlikowski 1992). In turn, when interpretive flexibility is low, the application of a certain technology is obvious to its users. This may render explanations and training optional or even obsolete. Yet, the user flexibility to choose the concrete usage of the technology is also restricted. For instance, ML technology embedded in the Google Photos Application allows users to search and filter their pictures according to themes such as ”beach” or “Christmas,” and there is little ambiguity concerning the technology’s features, purpose, and use cases.

Further, a technology’s interpretive flexibility for different stakeholders can be managed to navigate these extremes. Besides the design of the technology itself (Orlikowski 1992), prior work suggests that the *functional boundaries* of the focal technology can be adjusted by *enforcing* or *proscribing* certain applications of the technology (see Figure 1) (Doherty et al. 2006). For instance, the definition of mandatory and optional data input fields represents one way to manage the functional boundaries of a focal IT system for its stakeholders. Apart from top-down design, the collaborative design of boundary objects such as User Interfaces (UIs) or services allows multiple stakeholder groups to access an underlying technology (Steger et al. 2018). That is, the concrete ways users perceive the technology during use mode within its boundaries can, for example, be moderated through user engagement in the design mode of the technology (Doherty et al. 2006; Orlikowski 1992). User engagement may concern the design of general interfaces, but it may also concern feedback or requests on certain functionality and information being processed (Doherty et al. 2006). The technology and its boundaries are not static but are subject to change over time to adjust for the users’ needs, the technology provider’s goals, or changes in the underlying technology (Star 2010; Steger et al. 2018).

Digital Platform Ecosystems

Platform-based ecosystems have emerged as the dominant organizational form during the last decade. All major companies—ranging from Alphabet (i.e., Google) and Microsoft to Alibaba and Tencent—employ ecosystems of autonomous actors (Cusumano et al. 2020). Moreover, these companies build their businesses around an “extensible codebase of a software-based system that provides core functionality shared by the modules that interoperate with it and interfaces through which they interoperate” (Tiwana et al. 2010, p. 675). That is, digital platform ecosystems are organizational setups. They are software-driven, which enables them to engage with and integrate a multitude of autonomous actors (often referred to as *complementors* or *partners*) to create compelling value propositions for customers (Hein et al. 2019). Thereby, partners not only act as third-party developers that provide add-on pieces of software but also consult, sell, and implement the platform for users (Sarker et al. 2012; Wareham et al. 2014).

As the “locus of value creation moves from inside the firm to outside” (Parker et al. 2017, p. 263), platform firms employ specialized organizational designs. These designs are enabled by the modularity and complementarity of products and services provided by the platform and its various complementors (Jacobides et al. 2018; Tiwana 2015). To ensure the coherence and fit of multiple actors’ modular and complementary value propositions, the platform owner issues governance rules, which set the rules concerning decision making and gatekeeping, among others (Schreieck et al. 2016; Wareham et al. 2014). Besides the imposed rules and regulations, resources such as platform boundary resources provide partners with the technical and social resources necessary to deliver ever-increasing value to customers and potential customers while controlling their alignment (Ghazawneh and Henfridsson 2013).

Consequently, digital platform firms utilize particular organizational designs that allow them to manage value creation outside—rather than inside-out—and achieve unprecedented economic success. Thus, these designs leverage organizational and technological modularity to extend the production and innovation of their value propositions to realize the full potential of their core technology (Gawer 2014). The underlying process of opening up the platform’s core technology to third parties and managing the resulting third-party relationships can be explained using the theoretical lens of interpretive flexibility of technology.

Research Approach

We follow a single case study (Yin 2018) to focus on the case of Celonis the market leader in process mining (Kerremans 2019). Our longitudinal dataset allows us to investigate the changes implemented by Celonis to make their process mining technology available to a growing number of customers across different IT systems, business processes, industries, and regions over time. Finally, this period also comprises the extension of Celonis' technology portfolio from pure process mining to data-driven business process execution (termed Celonis Execution Management System (EMS)) based on process mining. Our case study thus provides a suitable and unique setting to investigate how a single organization adjusted and exploited the interpretive flexibility of its technology.

Case Overview and Data Collection

We collect data on the period between 2018 and 2021, with data collection still ongoing, comprising the key events of Celonis' success story and providing us with a rich longitudinal dataset. An overview of the case timeline with selected events is depicted in Figure 1.

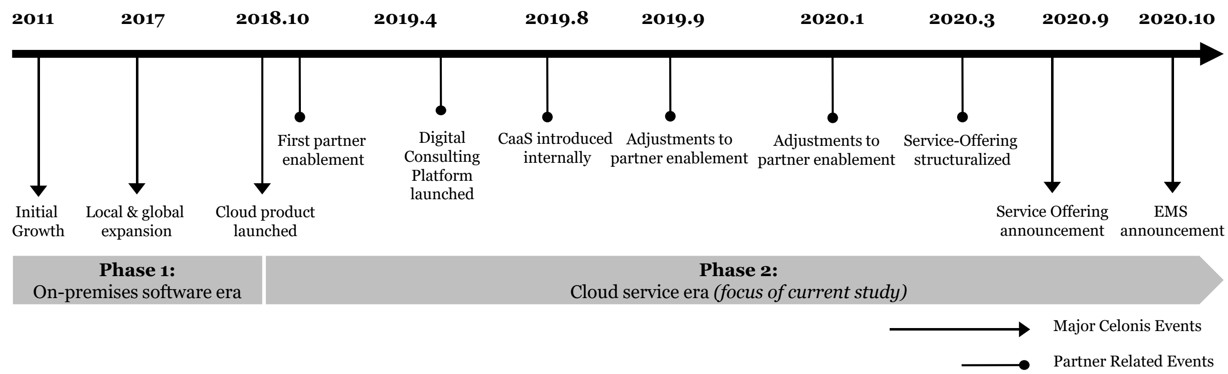

Figure 1 Overview of Selected Events on the Case Timeline

Between 2018 and 2021, Celonis not only gained unicorn status with a valuation of 2.5 billion $US in late 2019 but also built and scaled up its partner business. Also, Celonis grew the number of its employees from about 400 to more than 1200 during the focal period of our study. Our current dataset comprises 14 semi-structured interviews with representatives from Celonis as well as its partners. Eight interviews were conducted with Celonis representatives in general partner management and managers and engineers for consulting partners with an average length of 37 minutes. Six interviews with five different partner organizations were conducted with an average length of 46 minutes. Additionally, one of the authors has been an employee of Celonis since mid-2019 and tasked with managing consulting partners, co-developing different go-to-market strategies and services with them. Hence, the dataset also includes a multitude of meeting protocols, internal documents, communication, and memos. Regarding the period between mid-2018 and mid-2019, we collected additional internal documents and conducted informal interviews to gather relevant insights from experienced colleagues. Lastly, we augmented our primary data with publicly accessible secondary data from the company website, blog entries, and external communications.

Preliminary Data Analysis

After transcribing the interviews, we coded the interviews using open, axial, and selective coding. Applying these procedures, we conducted a qualitative content analysis (Miles and Huberman 1994). During our preliminary analysis, we first focused on the themes of partner enablement and governance as emphasized in the literature on digital platform ecosystems. From our data, we generate concrete insights into the mechanisms of bringing a broadly applicable technology, namely process mining to the market. For instance, to increase the access to the use of the technology Celonis created a broad ecosystem of various actors, including over 15.000 trained professionals, more than 250 partners, and over 300 universities. Together with its partners, Celonis co-developed different products and services iteratively addressing customer needs in various markets and segments. To enable its partners to leverage Celonis' technology, Celonis created and adjusted various enablement mechanisms over time reflecting the dynamic nature of ecosystem governance. As such, the interpretive flexibility and its management emerged as the unifying theme, facilitating data analysis in later stages and leading to the conceptualization of the proposed framework.

Preliminary Findings, Contributions, and Next Steps

Toward a Model for Managing Interpretive Flexibility

Based on the results of our in-depth case study, we derive a preliminary model that allowed us to identify and explore different mechanisms and strategies for managing a technology's interpretive flexibility. The model depicted in Figure 2 illustrates a continuum that allows the distinction between two extremes concerning the specificity of a technological solution.

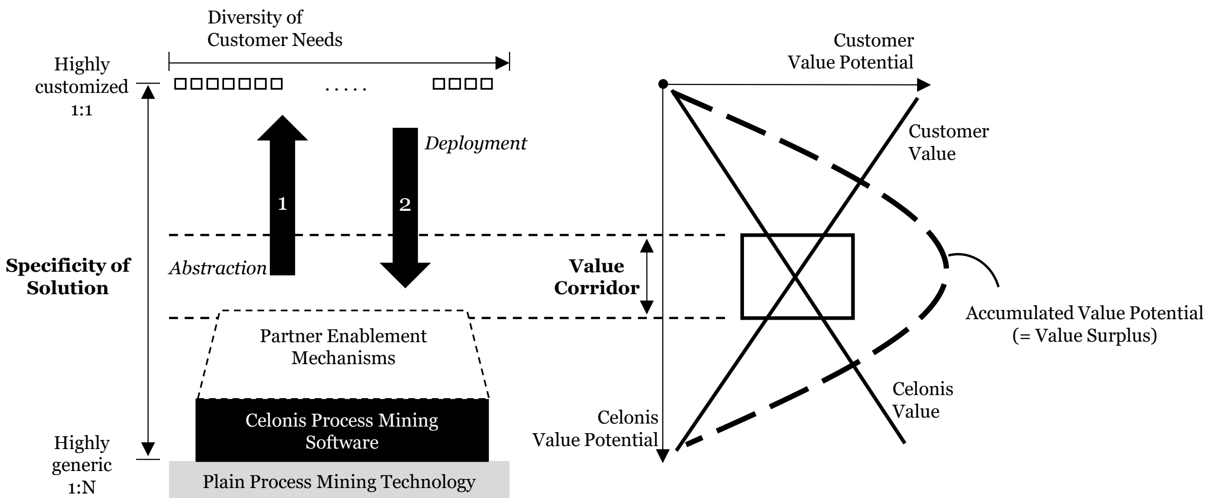

Figure 2 A preliminary model for managing interpretive flexibility of technology

On the top side of the continuum (1:1), the technological solution is highly customized to a single customer's needs (i.e., it has low interpretive flexibility) and cannot be transferred to other customers due to its degree of specificity. On the bottom side of the continuum (1:N), process mining as the plain process mining technology is highly generic and—while theoretically and potentially adjustable to any customer need, cannot readily solve any immediate customer need (i.e., it has high interpretive flexibility). Before describing the resulting framework depicted in Figure 2, it is important to emphasize that this is a highly stylized and relative conceptualization and serves as the basis for deriving generic instructions. Moreover, it reflects our preliminary findings and will be developed further according to our ongoing study.

From a value perspective, we can see that the value of the focal technology, namely process mining, depends on the focal actor. For instance, the value potential from the technology for Celonis is highest when the technology is more generic. That means, the technology can be applied to an almost infinite number of customer needs. This essentially describes Celonis' overall market potential concerning their process mining technology. Yet, to realize this potential, the technology needs to be adjusted and implemented for each use case separately, requiring dedicated resources like consultants that lower the overall, theoretical value potential. At the same time, the value potential for Celonis is lowest when process mining is in its highly customized form. This would allow Celonis to address only one single customer problem. This situation is reflected in the C*elonis Value* graph depicted on the right of Figure 2. Conversely, from a customer perspective, the value of process mining is the highest when the technology is configured to address their concrete use case, solving the customer problem immediately without further adjustments. On the opposite side of the continuum, the technology is too generic to be of high use-value to the customer as it does not readily solve the customer's problem. Again, this situation is depicted in the *Customer Value* graph on the right of Figure 2.

By integrating both value graphs concerning the *accumulated value potential of the technology* for Celonis and its (potential) customers, an inverted U-shape graph can be derived. The dashed line in Figure 2 describes the accumulated value potential of the technology through the lens of interpretive flexibility. The accumulated value is highest when the technology's interpretive flexibility is balanced and Celonis can offer its technology to many (but perhaps not all) customers, while many customers (but perhaps not all) can derive certain value from the technology's application.

From the graph, we derive a *Value Corridor* that allows us to balance the interests of Celonis and its potential customers around the peak of the accumulated value potential curve. Hence, Celonis is challenged with managing the interpretive flexibility of its process mining technology in a way that allows an increase in its value potential while addressing customer needs with concrete implementations. Naturally, Celonis needed to find ways to manage these diverging interests effectively and efficiently and stay *inside* the value corridor while doing so. Thus, the proposed model for managing interpretive flexibility allows us to investigate the strategies and mechanisms Celonis employed to manage and exploit the interpretive flexibility of their process mining technology while balancing diverse interests.

The Role of Celonis' Partner Ecosystem in Managing Interpretive Flexibility

Based on our data, we find, that at the core of Celonis' strategy is the collaboration with partners and the building up of a partner ecosystem around its technological core consisting of its process mining technology. Importantly, Celonis' technological core remained largely stable over time, while the products and services wrapped around the technology and the go-to-market strategies together with partners were subject to constant change along the company's nonlinear growth trajectory. The (re-)design and use of these products and services as vehicles of process mining technology are at the center of our analysis. To that end, our preliminary analysis focuses on two aspects: First, Celonis' efforts to enable its partners through *partner enablement mechanisms,* and second, the collaboration with partners in bringing Celonis' process mining to customers via deployment and abstraction (shown as arrows 1 and 2 in Figure 2).

The **partner enablement mechanisms** provided by Celonis comprise the rules and tools that help partners apply Celonis' solutions to customer problems or develop their applications. We find, that over time Celonis deployed a variety of different resources to support their partners and continuously develop the process mining market and increase their market share. These resources comprise online training and partner representative certification, workshops, webinars, and personal technical support. Celonis intensively engaged in co-developing different products and go-to-market strategies with its partners. These range from providing partners the software to equipping them with development resources and technical support to enable them in building applications based on their respective domain expertise.

Our data suggests there are two underlying mechanisms for delivering the Celonis technology to potential customers by **collaborating with partners**. First, these partners –usually consulting firms - use Celonis' software and apply it directly to a concrete customer problem within the scope of a consulting project. Leveraging the consultant's expertise in business processes, the merits of process mining can be delivered to various market segments, scaling Celonis' market potential while accommodating user needs. We term that mechanism to decrease interpretive flexibility *deployment* (arrow 1). To enable its partners to use Celonis technology in their consulting projects, Celonis in 2019 introduced a product called Celonis as a Service (CaaS), incorporating their technology in a software bundle that consultants could use in their consulting projects. In April 2021, Celonis initiated the Celonis for Consulting (C4C) Plus initiative, which aims at providing its technology to one million professionals worldwide, further lowering the barriers for consulting firms to use its software and simultaneously broadening its application space. Second, in 2020 Celonis and its partners co-developed a product called Service-Offering, which allowed partners to build a productized service from single customer projects and make their expertise available to other customers, too. We term that mechanism to increase interpretive flexibility *abstraction* (arrow 2). For instance, between late 2020 and early 2021, partners created 80 applications for Celonis EMS. To enable the co-creation of Service-Offering, Celonis and its partners collaborated intensely on technical and business model configurations, organizing multiple workshops and hackathons for selected partners to pilot the new product.

Contributions and Next Steps

Our study makes several initial contributions that can be generalized to other information technologies that exhibit ambiguity for users and a high degree of interpretive flexibility. The present work, therefore, informs the ongoing discussion on Artificial Intelligence (AI) or distributed ledger technologies that face similar challenges in their application and exploitation as process mining.

First, this study advances research on the interpretive flexibility of technology by taking the perspective of the designer of the focal technology as opposed to the prevailing user perspective (e.g., Orlikowski (1992), Sahay and Robey (1996), and Harandi et al. (2020)). Adding this view to extant research broadens our understanding of the origins of interpretive flexibility that results from purposeful design to address multiple users' needs. To that end, our preliminary model on the management of a technology's interpretive flexibility yields the great potential to advance the practical and scholarly debates around technology-related strategies and decision-making.

Second, we integrate the technical and organizational perspectives on digital platform ecosystems by showing that a platform ecosystem as an organizational design facilitates the delivery of an underlying technology platform to users (De Reuver et al. 2018; Gawer 2014). Through their organizational design based on partner enablement mechanisms and partner engagement, platforms mitigate the ambiguity caused through the interpretive flexibility of the underlying technology for users (Hein et al. 2019).

This study presents preliminary results and is part of a larger research endeavor, thus several limitations will be addressed while advancing this study. We are currently working with Celonis to expand data collection on the latest changes to its partner network and technology and build a longitudinal perspective. Further, our preliminary results only describe the most salient mechanisms in place. This is why the research team is planning to investigate all the different strategies and co-developed products and services between Celonis and its partners and answer the question of "how" Celonis managed interpretive flexibility of process mining in greater detail. Moreover, the impact of strategic partnerships and situations of conflicting interests are relevant aspects to be included as important environmental factors. Overall, we aim to develop and adjust the presented preliminary framework into a powerful model that helps technology companies assess and derive different go-to-market strategies and diverse models for collaboration with potential partners. The current short paper marks an early, but important milestone toward that goal.

Acknowledgments

The authors thank Celonis Digital Consulting and the Celonis Academic Alliance for their openness and support for this project.

References

Altinkemer, K., Ozcelik, Y., and Ozdemir, Z. D. 2011. "Productivity and Performance Effects of Business Process Reengineering: A Firm-Level Analysis," *Journal of Management Information Systems* (27:4), pp. 129-162 (doi: 10.2753/MIS0742-1222270405).

Cadili, S., and Whitley, E. A. 2005. "On the interpretative flexibility of hosted ERP systems," *Journal of Strategic Information Systems* (14:2), pp. 167-195 (doi: 10.1016/j.jsis.2005.04.006).

Chen, W., Zhang, C., Zheng, Y., and Cui, L. 2009. "The Interpretive Flexibility of an E-Government Project: From an Actor-Network Theory Perspective," in *Forty-Second Hawaii International Conference on System Sciences*: *HICSS 2009,* Waikoloa, HI, United States of America.

Cusumano, M. A., Yoffie, D. B., and Gawer, A. 2020. "The Future of Platforms," *MIT Sloan Management Review*.

De Reuver, M., Sørensen, C., and Basole, R. C. 2018. "The Digital Platform: A Research Agenda," *Journal of Information Technology* (33:2), pp. 124-135 (doi: 10.1057/s41265-016-0033-3).

Doherty, N. F., Coombs, C. R., and Loan-Clarke, J. 2006. "A re-conceptualization of the interpretive flexibility of information technologies: redressing the balance between the social and the technical," *European Journal of Information Systems* (15:6), pp. 569-582 (doi: 10.1057/palgrave.ejis.3000653).

Eggers, J., and Hein, A. 2020. "Turning Big Data Into Value: A Literature Review on Business Value Realization From Process Mining," in *Twenty-Eighth European Conference on Information Systems*: *ECIS 2020,* A Digital Conference.

Gawer, A. 2014. "Bridging differing perspectives on technological platforms: Toward an integrative framework," *Research Policy* (43:7), pp. 1239-1249 (doi: 10.1016/j.respol.2014.03.006).

Geyer-Klingenberg, J., Nakladal, J., Baldauf, F., and Veit, F. 2018. "Process Mining and Robotic Process Automation: A Perfect Match," in *Sixteenth International Conference on Business Process Management: Industrial Track*: *BPM 2018,* Sydney, Australia, pp. 124-131.

Ghazawneh, A., and Henfridsson, O. 2013. "Balancing platform control and external contribution in third-party development: The boundary resources model," *Information Systems Journal* (23:2), pp. 173-192 (doi: 10.1111/j.1365-2575.2012.00406.x).

Harandi, M., Crowston, K., Jackson, C., and Østerlund, C. 2020. "The Genie in the Bottle: Different Stakeholders, Different Interpretations of Machine Learning," in *Fifty-Third Hawaii International Conference on System Sciences*: *HICSS 2020,* Maui, HI, United States of America.

Hein, A., Schreieck, M., Riasanow, T., Setzke, D. S., Wiesche, M., Böhm, M., and Krcmar, H. 2019. "Digital platform ecosystems," *Electronic Markets* (30:1), pp. 87-98 (doi: 10.1007/s12525-019-00377-4).

Jacobides, M. G., Cennamo, C., and Gawer, A. 2018. "Towards a theory of ecosystems," *Strategic Management Journal* (39:8), pp. 2255-2276 (doi: 10.1002/smj.2904).

Jensen, T. B., and Aanestad, M. 2007. "Hospitality and hostility in hospitals: a case study of an EPR adoption among surgeons," *European Journal of Information Systems* (16:6), pp. 672-680 (doi: 10.1057/palgrave.ejis.3000713).

Kerremans, M. 2019. *Market Guide for Process Mining*. https://www.gartner.com/doc/reprints?id=1-SBXXPQO&ct=190625&st=sb. Accessed 21 April 2021.

Miles, M. B., and Huberman, A. M. 1994. *Qualitative Aata Analysis: An Expanded Sourcebook*, Thousand Oaks, CA, United Stated of America: SAGE Publications.

Orlikowski, W. J. 1992. "The Duality of Technology: Rethinking the Concept of Technology in Organizations," *Organization Science* (3:3), pp. 398-427 (doi: 10.1287/orsc.3.3.398).

Parker, G. G., van Alstyne, M. W., and Jiang, X. 2017. "Platform ecosystems: How developers invert the firm," *MIS Quarterly* (41:1), pp. 255-266.

Pinch, T. J., and Bijker, W. E. 1984. "The Social Construction of Facts and Artefacts: Or How the Sociology of Science and the Sociology of Technology Might Benefit Each Other," *Social Studies of Science* (14:3), pp. 399-441.

Reinkemeyer, L. 2020. *Process mining in action: Principles, use cases and outlook*, Cham, Ann Arbor: Springer; ProQuest eBook Central.

Sahay, S., and Robey, D. 1996. "Organizational context, social interpretation, and the implementation and consequences of geographic information systems," *Accounting, Management and Information Technologies* (6:4), pp. 255-282 (doi: 10.1016/S0959-8022(96)90016-8).

Sarker, S., Chatterjee, S., Xiao, X., and Elbanna, A. 2019. "The Sociotechnical Axis of Cohesion for the IS Discipline: Its Historical Legacy and its Continued Relevance," *MIS Quarterly* (43:3), pp. 695-719 (doi: 10.25300/MISQ/2019/13747).

Sarker, S., Sarker, S., Sahaym, A., and Bjørn-Andersen, N. 2012. "Exploring Value Cocreation in Relationships Between an ERP Vendor and its Partners: A Revelatory Case Study," *MIS Quarterly* (36:1), pp. 317-338 (doi: 10.2307/41410419).

Schreieck, M., Wiesche, M., and Krcmar, H. 2016. "Design and Governance of Platform Ecosystems – Key Concepts and Issues for Future Research," in *Twenty-Fourth European Conference on Information Systems*: *ECIS 2016,* Istanbul, Turkey.

Star, S. L. 2010. "This is Not a Boundary Object: Reflections on the Origin of a Concept," *Science, Technology, & Human Values* (35:5), pp. 601-617 (doi: 10.1177/0162243910377624).

Steger, C., Hirsch, S., Evers, C., Branoff, B., Petrova, M., Nielsen-Pincus, M., Wardropper, C., and van Riper, C. J. 2018. "Ecosystem Services as Boundary Objects for Transdisciplinary Collaboration," *Ecological Economics* (143), pp. 153-160 (doi: 10.1016/j.ecolecon.2017.07.016).

Tiwana, A. 2015. "Platform desertion by app developers," *Journal of Management Information Systems* (32:4), pp. 40-77 (doi: 10.1080/07421222.2015.1138365).

Tiwana, A., Konsynski, B., and Bush, A. A. 2010. "Platform evolution: Coevolution of platform architecture, governance, and environmental dynamics," *Information Systems Research* (21:4), pp. 675-687 (doi: 10.1287/isre.1100.0323).

van der Aalst, W. M. P. 2011. *Process mining*: *Discovery, conformance and enhancement of business processes*, Berlin: Springer.

van der Aalst, W. M. P. 2016. *Process mining: Data science in action*, Heidelberg: Springer.

Wareham, J., Fox, P. B., and Giner, J. 2014. "Technology ecosystem governance," *Organization Science* (25:4), pp. 1195-1215 (doi: 10.1287/orsc.2014.0895).

Yin, R. K. 2018. *Case study research and applications: Design and methods*, Los Angeles, London, New Dehli, Singapore, Washington DC, Melbourne: SAGE.

Appendix D. (P4) Partner Programs and Complementor Assessment in Ecosystem Governance: A Multiple-Case Study

Partner Programs and Complementor Assessment in Platform Ecosystems: A Multiple-Case Study

Completed Research

Martin Engert
fortiss GmbH &
Technical University of Munich
martin.engert@tum.de

Andreas Hein
Technical University of Munich
andreas.hein@tum.de

Helmut Krcmar
Technical University of Munich
helmut.krcmar@tum.de

Abstract

Digital platform ecosystems are an omnipresent phenomenon. Compared to traditional modes of interaction, digital pltaforms rely on complementary produts and services that autonomous partners provide . However, adequate measures to assess the output of complementors are not readily available and lack theoretical grounding. Thus, the goal of this paper is to explore and organize criteria and related metrics for the assessment of complementor outputs. We conduct a multiple-case study on 14 partner programs of B2B software platforms. Then, we develop a taxonomy comprising different complementor outputs in digital platform ecosystems. The taxonomy comprises 26 criteria for two complementor roles and respective metrics applied by platform owners for their evaluation. Furthermore, we describe characteristics of partner programs such as variations in assessment modes and intervals. Our findings support platform owners when creating and updating their partner programs and provide the basis for future work on the assessment of complementor ouput.

Keywords

Digital Platform Ecosystem, Partner Management, Governance, Assessment, Multiple Case Study

Introduction

Digital platforms have fundamentally changed the way we interact and conduct business. Through the digitization of business processes and increased availability, the trend toward a software-driven economy has been further accelerated. Companies with a digital platform such as Apple, Google, Microsoft, and Amazon are dominating the global economy, a circumstance referred to as the *platform economy* (Evans and Gawer 2016). The main reason for this dominating role is the utilization of network effects through the orchestration of interactions among multiple parties (Tiwana et al. 2010). In this role, the platform owner develops, oversees, and grows an ecosystem of autonomous actors around a stable and reliable core (Staykova 2018). The platform core provides a key functionality, which is consumed by users and extended through complementary services and applications (summarized as *complements*). Third-party developers (subsumed as *complementors* or *partners*) create those complements based on a focal value proposition (Hein et al. 2018; Manner et al. 2013; Tiwana et al. 2010). For instance, Salesforce provides a Customer-Relationship-Management (CRM) tool as the platform core functionality. In turn, third-party developers extend the CRM tool with consumable add-on services such as accounting, billing, and task monitoring applications. To facilitate value-creating mechanisms in the platform ecosystem, the platform owner implements governance mechanisms (Hein et al. 2019a). While governance mechanisms support value co-creation within the ecosystem, platform owners are challenged with limited transparency of complementor activities and knowledge on the status quo of the ecosystem (Fotrousi et al. 2014; Plakidas et al. 2017; Tiwana 2014). In this regard, partner programs are a governance mechanism that is being applied in the majority of software ecosystems, which creates transparency on complementors' contributions and performance levels using the assessment of complementors. Based on predefined requirements including revenue thresholds and platform certifications, platform owners can segment complementors individually into different partner levels. Each level is then associated with certain benefits for complementors such as rebates, closer collaboration opportunities, and conference invitations (Avila and Terzidis 2016; Wareham et al. 2014). Thus, partner programs categorize complementors based on an individual assessment.

However, while metrics-based approaches to ecosystem governance yield great potential for platform owners to make well-informed decisions, these approaches lack theoretical grounding (Fotrousi et al. 2014; Plakidas et al. 2017). Prior work on ecosystem governance mainly focused on qualitative aspects of governance, such as identification of mechanisms and processes (Hein et al. 2019c; Weiß et al. 2018). A platform owner, experiencing a decline in-app users, for instance, needs information on the app and service quality changes, such as customer satisfaction scores. Thus, the assessment of complementors as a basis for monitoring and decision-making is an important activity for platform owners, receiving modest attention in IS research. Therefore, we pose the following research question: *What are metrics-based approaches for the governance of complementors in digital platform ecosystems in practice?*

To answer this research question, we conduct a multiple case study of digital business-to-business (B2B) ecosystems and analyze their respective partner management programs to identify requirements and subsequent metrics for their partner assessment strategies. We present our findings in a taxonomy for complementor assessment in digital platform ecosystems.

Background

Digital Platform Ecosystems and Governance of Complementors

The concept of digital platforms and their ecosystems have been studied for more than a decade. In our understanding of digital platform ecosystems, we adhere to the recent definition of Hein et al. (2019a), who define digital platform ecosystems to comprise "[..] a platform owner that implements governance mechanisms to facilitate value-creating mechanisms on a digital platform between the platform owner and an ecosystem of autonomous complementors and consumers." This definition highlights governance mechanisms and their evolution as a central aspect to digital platform ecosystems from a platform owner's perspective.

Along the prototypical platform lifecycle following Tan et al. (2015), platform owners need different sets of capabilities for managing complementors. In a platform's early stages, owners must attract complementors to join the ecosystem and enable them to interact with the demand side to initiate network effects (Engert et al. 2019; Tan et al. 2015). Prominent examples of platforms failing to coordinate a sufficient level of interactions are Google Video and Yahoo Video (Schirrmacher et al. 2017). In the formative stage that follows, providing and refining boundary resources for complementors such as Software Development Kits (SDKs) and Application Programming Interfaces (APIs) is one of the main tasks for platform owners to align participants and steer platform evolution to be more open (Ghazawneh and Henfridsson 2013; Tan et al. 2015). At the same time, platform owners must focus on balancing different upcoming tensions in platform governance. Central tensions occur in the context of individual and standardized governance modes (Huber et al. 2017), competitive as opposed to cooperative approaches (Foerderer et al. 2018), and higher levels of autonomy compared to strict control (Boudreau 2010). An example of a platform failing to balance competitive and cooperative approaches was Sega in the videogame industry. It provided technical support and programming tools to internal developers before making them generally available, giving in-house production studios a significant heads-up. This made external developers leave the ecosystem because of an uneven playing field and ultimately fueled Sega's demise (Cennamo 2018). Finally, the maturity stage challenges owners with strengthening relationships among ecosystem participants and promoting collectivism within the platform, increasing dependability, and fostering lock-in (Tan et al. 2015).

Although this cycle does not apply to every platform setting, establishing and adjusting ecosystem-wide rules and norms along the evolution of a platform is essential for ecosystem governance of native and incumbent companies (Hein et al. 2019b; Schreieck et al. 2018).

Partner Programs for Governing Complementors

Partner management programs, often divided into partnership levels comprising specific entry-requirements and benefits, are one of the core mechanisms for platform owners to manage complementors (Wareham et al. 2014). These programs describe the rules for complementors to join ecosystems and participate in the transactions across the platform. Structuring and tailoring individual rights and duties within partner management programs is a common practice in digital ecosystems such as Salesforce, Microsoft Azure, Magento, and many others. Furthermore, these programs explicitly state the desired activities and contributions of complementors toward the ecosystem, thus being a rule-book for individual ecosystem behaviors as the basis for value co-creation (Sarker et al. 2012). These third-party activities include the development of new applications, selling and implementing products and services, as well as co-marketing activities (Hein et al. 2019a). Two key-characteristics of partner programs are to distinguish between different groups of partners based on their contributions to the ecosystem and their performance. For instance, partners with specific achievements may obtain prime access to new platform features, code libraries, or priority listing in a marketplace (Wareham et al. 2014). To be able to distribute complementors into these different partner levels, partner programs define entry requirements and thresholds for complementor performance. This poses a challenge to define meaningful criteria and metrics to assess complementors.

Assessment and Evaluation in Digital Platform Ecosystems

Research on digital platform ecosystems to date has focused on ecosystem-wide evaluation instead of individual assessments as shown in Table 1.

Concept	Measures	Description / Metrics	Source
Ecosystem Health	**Productivity**	Total Factor Productivity, Productivity Improvement Over Time and Delivery of Innovations	Iansiti and Levien (2004)
	Robustness	Survival Rates of Participants, Persistence of Ecosystem Structure, Limited Obsolescence and Continuity of Use Experience & Use Cases	
	Niche Creation	Variety, Value Creation	
Ecosystem Evolution	**Resilience**	Recovery Time After Outside Failure	Tiwana (2014)
	Scalability	Subsystem Latency, Responsiveness and Shift of Subsystem Financial Break-Even Point per 1.000 Users	
	Composability	Integration Effort [h] per internal change	
	Stickiness	Change in Hours per End-User Session, Change in Averaged End-User Sessions per Week over Time and Change in API Calls Made by an App on Avg. Over Time	
	Platform Synergy	Change in Number of Functions Called by App to APIs Unique to Platform	
	Plasticity	Avg. Count of Major Features Added per Release Over Lifetime	
	Envelopment	Count of Successful Envelopment Moves, Count of Envelopment Attacks Rebuffed and Percentage of New Subsystem Adopters Using Enveloped Functionality	
	Durability	Change [%] of a Subsystems Initial Adopters Remaining Active Users, Change [%] of Apps Released that are Subsequently Updated at Least Once a Year	
	Mutation	Number of Unrelated Derivative Platforms Relative to Rival Platforms, Carryover Users [%] at outset of Derivative Subsystems and Growth of an App Into a Platform	
Complementor Assessment		Engagement Level, Customer Satisfaction, Service Quality, Lead Conversion Rate, Continuity, Sustainability of Partner activities and Training Participation	Avila and Terzidis (2016)

Table 1 Prior Work on Assessment and Evaluation in Digital Ecosystems

Ecosystems are particularly difficult to assess because of their complexity and the level of signals and noise, which platform owners must make sense of (Tiwana 2014). However, metrics remain crucial for tracking and steering **ecosystem evolution**. Thus, Tiwana (2014) proposes nine criteria of evolution in platform ecosystems. Further, building on the early work of Iansiti and Levien (2004), several contributions have dealt with the assessment of **ecosystem health** as an overarching concept (e.g., den Hartigh et al. 2013 and Jansen 2014). Ecosystem health is assessed via productivity, robustness, and niche creation (Iansiti and Levien 2004). Despite the mentioned contributions, Hyrynsalmi and Mäntymäki (2018) note that the measures used to assess ecosystem health are mainly based on easy-to-collect metrics, and the fuzzy terminology around "ecosystems" leads to problems when comparing the results. Moreover, Fotrousi et al. (2014) conducted a literature analysis and found different KPIs for software ecosystems, clustering them along with their objectives, measured entities, and measurement attributes. They found that ecosystem actors — i.e., **complementors as one measured entity** — are regularly evaluated regarding their fulfilled tasks, decisions, and financial performance. This aspect has been stressed by Avila and Terzidis (2016), who emphasize the importance of continuous performance measurement as a core task in partner management of digital platform ecosystems. Furthermore, they highlight that a partner evaluation must be comprehensive and include an assessment of various criteria.

In sum, the literature on the evaluation and assessment is still scarce and focuses primarily on evaluating the overall ecosystem and its health or evolution. Further, work on individual assessment of complementors is in its infancy, with Avila and Terzidis (2016) being one of the few contributions mentioning metrics suitable for complementor assessment. Thus, this research aims at extending our understanding by examining assessment strategies for complementors from practice.

Research Design

To better understand the strategies applied by digital platform owners when assessing their complementors within partner programs, we conducted a multiple case analysis on partner programs of digital platform ecosystems with 14 cases, as shown in Table 2 (Eisenhardt 1989; Yin 2018). We used 11 partner programs of B2B software platforms, which are publicly accessible and augmented with three partner programs that ask complementors to request information on partnering possibilities. Thus, we pseudonymized the names of these companies. The cases selected are digital platform ecosystems in the B2B domain, more precisely all of them are software platforms. The cases differ, however, regarding their specific industry, overall size, type of partners, and the number of partners. These differences allow us to draw important cross-case results, leading to generalizable conclusions.

#	Company Name	#	Company Name	#	Company Name
1	Dell Technologies	6	ServiceNow	11	Magento
2	Proofpoint	7	Snow Software	12	*Commerce Corp.*
3	Red Hat	8	Vidyo	13	*Pricing Corp.*
4	Salesforce	9	VMware	14	*Security Corp.*
5	SAS	10	Zuora		

Table 2 Companies included in the Multiple Case Study

A multiple-case analysis is suitable for this inquiry because we aim to describe complementor assessment criteria and associated metrics from practice to extend research on the governance of digital platform ecosystems (Benbasat et al. 1987). Based on the multiple case study, we develop a taxonomy for complementor assessment in three iterations, applying an empirical-to-conceptual approach as proposed by Nickerson et al. (2013). As the meta-characteristic, we chose the criteria for partner management programs for assessing complementors. In addition to the objective ending conditions proposed by Nickerson et al. (2013), we defined three subjective ending conditions. First, the final taxonomy should be comprehensive for all partner programs we examined. Second, the taxonomy must be extendible for future work on complementor assessment. Lastly, the final taxonomy must be concise regarding its single items. The objective ending conditions ensure the generalizability and completeness of our findings from all cases.

Partner programs are a rich source of information on complementor governance and the rules and measures applied by platform owners. Information on partner programs is communicated via company websites using explicit partner program guides or partner program presentations. We followed the guidelines of Yin (2018) regarding sampling strategy, data collection, and analysis. Further, we augmented this approach with selected procedures for coding from grounded theory, according to Corbin and Strauss (1990). Thus, we applied open, axial, and selective coding when deriving the taxonomy from the available data, as shown in Table 3 and iterating to arrive at an exhaustive taxonomy, which met our initial ending criteria.

Excerpt from Partner Programs	Concepts	Categories
„Platinum partners must name an executive sponsor to discuss partnership status and the joint business plan on a regular basis with their SAS executive sponsor."	1. Executive sponsor [y/n] 2. Joint business plan [y/n]	• Assignment of executive sponsor, [y/n] • Joint business planning [y/n; quarterly/annually]
"Gold and Platinum partners are expected to participate in quarterly business reviews jointly with Proofpoint."	3. Business review [quarterly]	• Joint business planning [y/n; quarterly/annually]

Table 3 Illustration of Coding Scheme

Results

Characteristics of Partner Programs in Digital Platform Ecosystems

Based on the analysis of the partner management programs, we first identified four general characteristics of partner management programs in the domain of B2B software platforms. First, all partner management programs comprise several **partner levels**. The most common structure of partner levels is three-level or four-level systems. Usually, there is a *Basic* or *Registered* level for newly registered entrants with only minimal requirements such as signing an agreement, choosing a partner category, and creating a partner profile. Further, the programs comprise two or three partner levels beyond the basic level with similar activities but different requirements regarding their performance levels. These levels are usually labeled *Bronze*, *Silver*, and *Gold* or *Platinum*. Overall, programs have little differences in structure.

Second, most partner management programs we studied differentiated two **partner roles** complementors can take. On one hand, there are *Sales and Implementation* partners, which are characteristic of B2B contexts. Complementors in this role are often technical consultancies, which approach potential customer firms to sell the platform core product and some additional features to them. Additionally, they implement and fit the product sold to these customers' needs and the current IT landscape. On the other hand, there are *Development* partners. These partners provide applications and digital services to the customers via the platform. Salesforce AppExchange is a well-known example of such a marketplace. While development partners significantly broaden the scope of the platform value proposition, not all platforms have this kind of partnership in their partner programs. However, every partner program we studied provided for sales and implementation partners.

Third, the **assessment interval** is one critical differentiator between partner programs. The basic assessment period for partners in all partner programs is one year. That is the time at which platform owners evaluate if a partner may stay in their assigned level or must move up or down. Many programs have an annually *fixed* assessment interval, with a determined date for partner evaluation. Opposed to fixed assessment, *rolling* assessment is a dynamic approach to partner performance evaluation. Rolling assessment is based either on a quarterly or a daily performance measure, considering the performance of the last four quarters or 365 days of the partnership, respectively. Only two of our studied cases applied daily rolling assessment intervals within their partner programs, showing the increasing complexity of daily performance assessment.

Lastly, we found that partner programs differ in their **assessment mode**. Most platforms apply a *checklist* approach, meaning a static check if all requirements for a certain partner-level have been met. If one requirement could not be met, the complementor fails to move up or stays within their current level. Further, we found that four of the examined cases applied *aggregated* assessment modes. The most prominent case performing an aggregated complementor performance assessment is Salesforce with its "Consulting Partner Trailblazer Score." Salesforce uses a scoring system with predefined and weighted categories and sub-categories as well as maximum points to be achieved in these categories. This leaves complementors the choice of specialization to accumulate points in different areas, increasing complementor heterogeneity within the ecosystem.

Evaluation Criteria and their Metrics in Performance Assessment

The evaluation criteria and related metrics within partner management programs to assess complementors differ from platform to platform and depend on the chosen partner role of the respective complementor. At the same time, these criteria are evaluated in every assessment interval using a predefined assessment mode. Some criteria are assessed only for complementors in more advanced partner levels. Table 4 depicts the taxonomy of the complementor assessment derived from the multiple case study.

General Criteria

As general criteria, we identified measures that are important to establish a close, collaborative **relationship** between platform owner and complementor. As such, almost all platforms required complementors of higher partner levels to engage in annual or quarterly joint business planning for close strategic alignment. For example, SAS uses joint business planning to set revenue goals, marketing activities, and support activities to get there. Another criterion is the assignment of dedicated employees to coordinate the partnership efforts, which are assessed via the number and positions of the assigned employees. Higher-level partners must further assign an executive-level sponsor, who joins business planning and discuss partnership status to force higher levels of partner commitment. Snow Software, which provides software for software asset management, includes a *Platinum Plus* Partnership. This demands partners to work with Snow Software exclusively. This criterion is unique to Snow Software's Partner Program.

Criteria for Sales and Implementation Partners

For partners in the sales and implementation role, we distinguish between three categories of criteria, as shown in Table 4, which are expertise, performance and marketing-related.

		Criteria	Metric / Example
Relationship		Joint Business Planning	y / n [quarterly / annually]
		Assignment of Employees	# of Employees Assigned; Types of Employees Assigned
		Exclusivity to Platform	y /n
		Assignment of Executive Sponsor	y/n
Sales & Implementation	Expertise	Certification of Organization	# of Certifications; Types of Certifications
		Certification of Employees	# of Certified Employees; # of Certifications of Employees [overall or individually]; Types of Certifications; # of Certified Employees
		Growth in Certified Employees	% Growth-Rate of # of Certified Employees
		Training for Employees	# of Trainings Taken Type of Training
	Performance	Successful Implementations	# of Successful Implementations
		Referenceable Customers	# of Referenceable Customers
		Basic Revenue	in US$
		Annual Contract Value (ACV)	in US$
		New Business Proportion of Revenue	in US$
		Deal Volume of Referrals/Deals	in US$
		Growth of Revenue / ACV	% Growth-Rate of Revenue/ACV
		Customer Success Stories Submitted	# of Customer Success Stories Submitted
		Customer Satisfaction Score (CSAT)	Min. Points within Predefined Scale
	Marketing	Provision of Marketing Material	Sales Battlecard; Data Sheet; Presentation; Service Catalog
		Co-Marketing Activities	Co-Branding on Website; # of Co-Marketing Activities/Campaigns
		Financial Marketing Commitment	in US$
Development	Expertise	Use of Latest Platform Technology	y/n
		Certification of Application	Types of Certifications; Show Self-Validation Test Plan and Results
	Performance	Provision of Application	y/n
		Users of Application	# of Application Users
		Installations by New Customers	# of New Customer Installations
		Provision of Customer Support	y/n

Table 4 Taxonomy of Complementor Assessment

For one, complementors engaging in sales and implementation activities are assessed regarding their respective **expertise** in different areas. Every platform we examined provided specific certification programs for complementors to acquire and demonstrate their expertise in technical and sales-related fields. Certifications can usually be acquired for individual employees or the complementor as an organization. Metrics for evaluation of these criteria are based on the number and type of certification and/or the number of newly certified employees. Notably, Salesforce used the growth in the number of certified employees as a separate criterion, providing one of the few relative measures found in our analysis.

However, the core assessment for sales and implementation complementors is related to **performance** measures. Typically, the total annual revenue created or annual contract value is evaluated, often in combination with a particular growth-related assessment component. This urges partners to onboard new customers to the ecosystem, thus fueling ecosystem growth. Additionally, two criteria related to customer success were identified. First, partners must submit a certain number of customer success stories, often to be published or used as references in marketing by the platform owner. Second, a minimum level of customer satisfaction ratings based on customers' reviews of complementors is a prominent measure in complementor performance assessment and an important tool for the platform owner to ensure platform quality. Besides expertise and performance-related measures, platform owners included **marketing-**related activities in their assessments. These range from a fixed financial contribution of complementors to the platform owner for marketing activities to organizing co-marketing activities via a predefined number of coordinated campaigns. Further, the provision of marketing material to the platform owners as product and service catalogs, presentations, and other documents is a common criterion, having checklist format.

Criteria for Development Partners

Complementors that chose the development role are assessed along with expertise and performance categories. First, assessment of complementor performance in this role surrounds **expertise** in development. This category comprises whether a developing complementor uses the latest platform technology. This is important to control the compatibility of complements and the provision of the latest platform functionalities to consumers via the complements. Additionally, development expertise is assessed via the certification of applications, either via certain types of certifications such as app performance and security or provision of a self-validated test plan and its results. Certification of applications in the marketplace helps platform owners secure platform quality.

The second category refers to development **performance**. Development performance is assessed using four criteria. Partner programs first require a complementor to provide an application as a first prerequisite for entering the development partner tier. Further, we find that performance is assessed through the number of users of a complementor's applications and the number of new customer installations. The fourth criterion used to assess the performance of developing complementors listed in the partner programs we examined was whether a complementor provided customer support for their applications and services.

Discussion

Integration with Measures for Ecosystem Health

The results of our empirical study show a strong focus on individual complementor assessment compared to existing evaluation approaches for ecosystem health and ecosystem evolution. In particular, we find similarities in the evaluation of productivity in the context of ecosystem health (Iansiti and Levien 2004), which is equivalent to the assessment of performance in our findings. However, our results found no suitable measure for robustness, which is the second subset of ecosystem health assessment (see Table 1). This aspect may be added to partner programs of digital platform ecosystems to account for the robustness of individual relationships. Still, suitable metrics need to be defined to assess the robustness of individual relationships. Further, prior work has applied 'variety of projects' in open source communities as a metric for variety within Niche Creation (Jansen 2014), which is the third subset of ecosystem health (see Table 1). We propose the use of measures of expertise such as certifications to assess the variety of resources available to the ecosystem (see Table 4), instead of the variety of ongoing activities, such as projects. This new perspective will advance our understanding of ecosystem health as a measure of the resources available instead of the activities at a certain point in time.

Internal and External Evaluation in Digital Platform Ecosystems

Prior work on the assessment of digital platform ecosystems has focused on internal evaluation criteria, solely accounting for interactions within the ecosystem. For instance, research on ecosystems used ecosystem health as an internal measure (e.g., Jansen 2014 and den Hartigh et al. 2013), excluding factors external to the ecosystem, such as competition. Tiwana (2014) proposes measures to track ecosystem evolution using only internal ecosystem characteristics as measures (see Table 1). Research on assessing individual complementors faces a similar constraint. When consolidating KPIs for software ecosystems, Fotrousi et al. (2014) identify only three criteria for complementors: fulfilled tasks, decisions, and profits. However, these criteria again are focusing on ecosystem internal activities. Finally, Avila and Terzidis (2016) posit that comprehensive partner management must evaluate complementors' engagement level, new customer acquisitions through complementors, lead conversion rate, continuity, sustainability, customer acquisition, and participation in trainings. While these criteria also take an external perspective while still focusing on internal ecosystem interactions. Our results showed that, except for marketing campaigns, complementors' assessment criteria mainly focus on internal ecosystem interactions. External interactions, which might create value for the ecosystem, are not included in these evaluations. Thus, we recommend extending the focus of complementor evaluation to include additional external engagement behaviors, which bears opportunities for a comprehensive evaluation of complementor engagement.

Interactions of Complementor Roles

Partner programs largely distinguish between two general roles for complementors. Sales and implementation partners focus on new customer acquisition and subsequent implementation and customization. In contrast, development partners are tasked with the creation of complements for the core product such as applications, analysis or related services. Complements are either easily integrated into the system implementation of users via download and installation or must be integrated into these systems by specialists. This situation creates dependencies and interactions between complementors of both roles. First, sales and implementation partners need the complements of development partners when creating sales leads and highlighting the value proposition of the software product. Second, development partners need sales and implementation partners to advocate their solutions as important platform features and, possibly, their integration in customer systems. Following Avila and Terzidis (2016), assessing the engagement level of complementors is key for effective partner management. Therefore, platform owners must include the interactions of complementors with each other, particularly with complementors taking other roles. Interactions among complementors can be evaluated via collaboration-related measures such as documentation or training offered by developing complementors to selling and implementing complementors to support their activities. In turn, selling and implementing complementors' interactions with developing complementors can be assessed, for instance, using feature or app requests made via a central forum to developing complementors. Enabling and controlling these exchanges through the provision of tools for open communication between the groups is a key priority for the platform owner.

Conclusion, Opportunities for Future Work and Limitations

Applying a multiple case study approach, this work investigated criteria and metrics for assessment of complementors in digital platform ecosystems based on an analysis of requirements within partner programs of B2B software platforms. By following the guidelines of Nickerson et al. (2013), we developed a taxonomy for complementor assessment. We identified characteristics of partner programs and their respective manifestations. Furthermore, we found and organized criteria for complementor assessment and their respective metrics.

Our insights have important implications for platform owners and complementors alike. First, platform owners must produce suitable partner management programs when creating new platforms. Further, continuous evolution and regular updates to the program's policies and structure are important to engage complementors. Thus, building on our typology of requirements and possible metrics for their assessment is greatly helpful for creating and innovating partner programs. Second, among others, complementors can use these metrics to self-track their performance before and after entering digital platform ecosystems. Providing measures for complementors based on the metrics that are used in a diverse set of digital ecosystems helps complementors assess suitable ecosystems to join. We contribute to research on digital platform ecosystems through an analysis of partner programs as a mechanism for governance of third-parties. Particularly, this study contributes to ongoing work on assessment and KPIs in software ecosystems through analysis of 14 cases and organizing criteria and metrics used in practice. Thus, this contribution serves as the basis for future work on the assessment of complementors and governance of digital platform ecosystems.

Based on our findings, we propose two opportunities for future research. First, the current assessment approaches focus on evaluating internal ecosystem activities. Future work may evaluate the potential of extending this focus to complementor engagement behaviors outside ecosystems, such as knowledge sharing and its value to the ecosystem. Developing research on engagement, researchers may collect and systemize possible complementor engagement behaviors and evaluate their value toward ecosystems. Relevant activities could be integrated into existing practices of complementor assessment. Second, research on the management of digital platform ecosystems based on different metrics and KPIs remains scarce. Platform owners need tools to assess and analyze complementors individually and collectively to monitor their ecosystems and draft effective strategies. Therefore, future work should investigate data and metrics available to platform owners and how they can be used and combined to provide valuable information and knowledge on digital platform ecosystems and the individual complementors within them. Nonetheless, this work has several limitations. First, the sampling of our multiple case study was limited through the restricted access to partner programs of some platforms and, thus, may be subject to a sampling bias. We mitigated this drawback by an increased number of cases to adjust for possible sampling errors. Second, platform owners may use additional metrics for assessing complementors in their ecosystems than stated in their partner programs. Future research may extend this case study with more data for further validation.

Acknowledgments

This work was supported by the Bavarian Ministry of Economic Affiards, Regional Development and Energy under the BayernCloud III project (grant. No. 20-13-3410-I.01A-2017).

References

Avila, A., and Terzidis, O. 2016. "Management of Partner Ecosystems in the Enterprise Software Industry," in *Eighth International Workshop on Software Ecosystems co-located with Tenth International Conference on Information Systems (ICIS 2016), Dublin, Ireland, 2016*.

Benbasat, I., Goldstein, D. K., and Mead, M. 1987. "The Case Research Strategy in Studies of Information Systems," *MIS Quarterly* (11:3), pp. 369–386.

Boudreau, K. J. 2010. "Open platform strategies and innovation: Granting access vs. devolving control," *Management Science* (56:10), pp. 1849–1872.

Cennamo, C. 2018. "Building the Value of Next-Generation Platforms: The Paradox of Diminishing Returns," *Journal of Management* (44:8), pp. 3038–3069.

Corbin, J. M., and Strauss, A. 1990. "Grounded theory research: Procedures, canons, and evaluative criteria," *Qualitative Sociology* (13:1), pp. 3–21.

den Hartigh, E., Visscher, W., Tol, M., and Salas, A. J. 2013. "Measuring the health of a business ecosystem," in *Software Ecosystems: Analyzing and Managing Business Networks in the Software Industry*, Slinger Jansen, M. A. Cusumano and S. Brinkkemper (eds.): Edward Elgar Publishing, pp. 221–246.

Eisenhardt, K. M. 1989. "Building Theories from Case Study Research," *The Academy of Management Review* (14:4), pp. 532–550.

Engert, M., Pfaff, M., and Krcmar, H. 2019. "Adoption of Software Platforms: Reviewing Influencing Factors and Outlining Future Research," in *Twenty-Third Pacific Asia Conference on Information Systems,* Xi'An, China.

Evans, P. C., and Gawer, A. 2016. *The Rise of the Platform Enterprise A Global Survey*. Technical Report, Center for Global Enterprise. https://www.thecge.net/app/uploads/2016/01/PDF-WEB-Platform-Survey_01_12.pdf. Accessed 21 April 2020.

Foerderer, J., Kude, T., Mithas, S., and Heinzl, A. 2018. "Does Platform Owner's Entry Crowd Out Innovation? Evidence from Google Photos," *Information Systems Research* (29:2), pp. 444–460.

Fotrousi, F., Fricker, S. A., Fiedler, M., and Le-Gall, F. 2014. “KPIs for Software Ecosystems: A Systematic Mapping Study,” in *Fifth International Conference on Software Business*, C. Lassenius and K. Smolander (eds.), Paphos, Cyprus, pp. 194–211.

Ghazawneh, A., and Henfridsson, O. 2013. “Balancing platform control and external contribution in third-party development: The boundary resources model,” *Information Systems Journal* (23:2), pp. 173–192.

Hein, A., Böhm, M., and Krcmar, H. 2018. “Tight and Loose Coupling in Evolving Platform Ecosystems: The Cases of Airbnb and Uber,” in *Business Information Systems*: *BIS 2018*, W. Abramowicz and A. Paschke (eds.), Cham, Switzerland: Springer, pp. 295–306.

Hein, A., Schreieck, M., Riasanow, T., Setzke, D. S., Wiesche, M., Böhm, M., and Krcmar, H. 2019a. “Digital platform ecosystems,” *Electronic Markets* (30:1), pp. 87–98.

Hein, A., Schreieck, M., Wiesche, M., Böhm, M., and Krcmar, H. 2019b. “The emergence of native multi-sided platforms and their influence on incumbents,” *Electronic Markets* (29:4), pp. 631–647.

Hein, A., Weking, J., Schreieck, M., Wiesche, M., Böhm, M., and Krcmar, H. 2019c. “Value co-creation practices in business-to-business platform ecosystems,” *Electronic Markets* (29:3), pp. 503–518.

Huber, T. L., Kude, T., and Dibbern, J. 2017. “Governance practices in platform ecosystems: Navigating tensions between cocreated value and governance costs,” *Information Systems Research* (28:3), pp. 563–584.

Hyrynsalmi, S., and Mäntymäki, M. 2018. “Is Ecosystem Health a Useful Metaphor? Towards a Research Agenda for Ecosystem Health Research,” in *Challenges and Opportunities in the Digital Era - IFIP I3E 2018*, S. A. Al-Sharhan, A. C. Simintiras, Y. K. Dwivedi, M. Janssen, M. Mäntymäki, L. Tahat, I. Moughrabi, T. M. Ali and N. P. Rana (eds.), Cham, Switzerland: Springer, pp. 141–149.

Iansiti, M., and Levien, R. 2004. “Strategy as Ecology,” *Harvard Business Review* (82:3), pp. 68–78.

Jansen, S. 2014. “Measuring the health of open source software ecosystems: Beyond the scope of project health,” *Information and Software Technology* (56:11), pp. 1508–1519.

Manner, J., Nienaber, D., Schermann, M., and Krcmar, H. 2013. “Six Principles for Governing Mobile Platforms,” in *Eleventh International Conference on Wirtschaftsinformatik,* Leipzig, Germany.

Nickerson, R. C., Varshney, U., and Muntermann, J. 2013. “A method for taxonomy development and its application in information systems,” *European Journal of Information Systems* (22:3), pp. 336–359.

Plakidas, K., Schall, D., and Zdun, U. 2017. “Evolution of the R software ecosystem: Metrics, relationships, and their impact on qualities,” *Journal of Systems and Software* (132), pp. 119–146.

Sarker, S., Sarker, S., Sahaym, A., and Bjørn-Andersen, N. 2012. “Exploring Value Cocreation in Relationships Between an ERP Vendor and its Partners: A Revelatory Case Study,” *MIS Quarterly* (36:1), pp. 317–338.

Schirrmacher, N.-B., Ondrus, J., and Kude, T. 2017. “Launch Strategies of Digital Platforms: Platforms With Switching and Non-Switching Users,” in *Twenty-Fifth European Conference on Information Systems,* Guimarães, Portugal.

Schreieck, M., Wiesche, M., and Krcmar, H. 2018. “Multi-Layer Governance in Platform Ecosystems of Established Companies,” in *Academy of Management Proceedings,* Chicago, Illinois, USA.

Staykova, K. S. 2018. “Managing Platform Ecosystem Evolution through the Emergence of Micro-strategies and Microstructures,” in *Twenty-Sixth European Conference on Information Systems,* Portsmouth, United Kingdom.

Tan, B., Pan, S., Lu, X., and Huang, L. 2015. “The Role of IS Capabilities in the Development of Multi-Sided Platforms: The Digital Ecosystem Strategy of Alibaba.com,” *Journal of the Association for Information Systems* (16:4), pp. 248–280.

Tiwana, A. 2014. *Platform ecosystems*: *Aligning architecture, governance, and strategy*, Amsterdam et al., Netherlands et al.: Morgan Kaufmann.

Tiwana, A., Konsynski, B., and Bush, A. A. 2010. “Platform evolution: Coevolution of platform architecture, governance, and environmental dynamics,” *Information Systems Research* (21:4), pp. 675–687.

Wareham, J., Fox, P. B., and Giner, J.L.C. 2014. “Technology ecosystem governance,” *Organization Science* (25:4), pp. 1195–1215.

Weiß, N., Schreieck, M., Wiesche, M., and Krcmar, H. 2018. “Setting Up a Platform Ecosystem - How to integrate app developer experience,” in *IEEE International Conference on Engineering, Technology and Innovation (ICE/ITMC),* Stuttgart, Germany.

Yin, R. K. 2018. *Case study research and applications: Design and methods*, Los Angeles, London, New Dehli, Singapore, Washington DC, Melbourne: SAGE.

Appendix E. (P5) Enabling Partner Management in Enterprise Platform Ecosystems - A Design Science Research Study

Enabling Partner Management in Enterprise Platform Ecosystems - A Design Science Research Study

Completed Research Paper

Martin Engert
Technical University of Munich
Boltzmannstrasse 3
85748 Garching, Germany
martin.engert@tum.de

Jonathan Fuchs
Technical University of Munich
Boltzmannstrasse 3
85748 Garching, Germany
fuchsjon@in.tum.de

Andreas Hein
Technical University of Munich
Boltzmannstrasse 3
85748 Garching, Germany
andreas.hein@tum.de

Helmut Krcmar
Technical University of Munich
Boltzmannstrasse 3
85748 Garching, Germany
helmut.krcmar@tum.de

Abstract

Partner management is an important success factor for digital platform ecosystems. It operationalizes the platform partner strategy, making far-reaching decisions concerning value co-creation and mitigating governance tensions. However, tools to support partner managers in their tasks have received little attention. Using design science research, we develop a tool prototype that is capable of supporting partner managers through computation, provision, and visualization of relevant information. We analyze the literature and conduct nine interviews with partner managers from three enterprise software platform firms to identify requirements in four task areas. This paper presents the first design cycle comprising seven realized requirements. We present and evaluate the IT-artifact using a simulation. Our findings highlight the need for information in platform governance and demonstrate the artifact's ability to address practical needs and provide valuable IT-based decision support. We contribute to the literature on the governance of complementors and support practitioners with an effective tool.

Keywords: Digital Platform Ecosystems, Partner Management, Information Capacity, Decision Support Tool, IT-artifact

Introduction

In the past decade and beyond, digital platform ecosystems as manifestations of digital technologies have reshaped the ways we conduct business. Enterprises rely on platforms in their daily work (e.g., SAP Cloud Platform), the management of business processes (e.g., ServiceNow), or the use of external computing power (e.g., Amazon Web Services). Platform firms build on a vast network of partners, also referred to as *complementors* (we will use both terms interchangeably throughout this paper), to scale their sales reach and extend platform functionalities (De Reuver, Sørensen, & Basole, 2018; Yoffie

& Kwak, 2006). The platform core provides the basic functionality demanded by the majority of users. For example, the Salesforce platform offers Customer Relationship Management (CRM) at its core, while partners' applications provide specialized functions such as loyalty program automation. Besides applications, partners also engage in reselling, consulting, implementing the platform, or offering managed services (Wareham, Fox, & Giner, 2014). Using governance mechanisms, the owner aligns and manages the ecosystem of partners driving value co-creation (Hein, Weking, et al., 2019; Tiwana, Konsynski, & Bush, 2010). The ongoing process of active and reactive platform governance involves multiple trade-offs that need to be carefully balanced by the platform owner (Huber, Kude, & Dibbern, 2017; Parker, van Alstyne, & Jiang, 2017). For instance, platform owners need to find a balance between easy access associated with an increase in the number of partners and the level of exercised control associated with the quality of partners (Boudreau, 2010).

To assess the status quo and decide on the course of action, platform owners establish information capacities, which allow them to produce, manage, and distribute information (Wang, 2021). Thus, metrics and Key Performance Indicators (KPIs) are an important aspect in managing partner ecosystems (Engert, Hein, & Krcmar, 2020; Fotrousi, Fricker, Fiedler, & Le-Gall, 2014). Generally, platform owners define and monitor relevant KPIs based on the key activities of their partners and derive information accordingly. Hence, the platform partner managers must be enabled to process this information efficiently and on time to make appropriate decisions concerning initial partner choice, partnership ramp up, and continuous development (Avila & Terzidis, 2016; Plakidas, Schall, & Zdun, 2017; Wang, 2021).

However, little research exists on the assessment of partners and the role of information in partner-related decision making (Engert et al., 2020; Graça & Camarinha-Matos, 2017; Senyo, Liu, & Effah, 2019). Providing appropriate guidance on the information needed and how it serves partner managers in their daily tasks, not only advances our understanding of platform information capacity but also strengthens practitioners' information-based partner management. Moreover, despite Information Technology-enabled (IT) tools being known to provide efficient decision support, there have been no investigations into tool support for the governance of partners in digital platform ecosystems (Fotrousi et al., 2014). IT-based tools would facilitate the continuous evaluation of partners and the monitoring of the consequences of governance decisions for platform owners based on appropriate KPIs (Blasco-Arcas et al., 2020; Wang, 2021).

Therefore, the goal of this paper is to present a tool prototype that is capable of supporting platform owners in governing and managing their partners by enhancing informed decision-making based on relevant information. To that end, we apply a Design Science Research (DSR) (Hevner, March, Park, & Ram, 2004; Peffers, Tuunanen, Rothenberger, & Chatterjee, 2007) approach to extract requirements from the literature and use interviews with partner managers to create a novel artifact and solve the practical problem of KPI-based decision making in practice. For the requirements, we conducted interviews with nine partner managers from three digital platform firms in the enterprise software industry, which resulted in 16 specific requirements for our artifact. In our first DSR iteration, we implemented seven of these requirements and evaluated the tool using scenario-based simulation (Peffers, Rothenberger, Tuunanen, & Vaezi, 2012; Venable, Pries-Heje, & Baskerville, 2012). With this study, we contribute to research on digital platform ecosystems and the recently intensified discussion on information-based ecosystem management and the information capacity of platforms (Engert et al., 2020; Wang, 2021). Besides the identification of five governance tensions from the literature, we contribute the first practical insights into the tasks and needs of partner management and the metrics and KPIs needed to operationalize a platform's partner strategy. Moreover, by contributing a software-based prototype tool to research and practice, we attempt to expand this discussion towards decision support systems. Also, we provide practitioners with the first version of an applicable open-source IT-artifact based on the completion of our first DSR iteration (Peffers et al., 2007).

DSR Step 1: Background and Related Work

Digital Platform Ecosystems and Partner Management

A digital platform ecosystem comprises "a platform owner that implements governance mechanisms to facilitate value-creating mechanisms on a digital platform between the platform owner and an ecosystem of autonomous complementors and consumers" (Hein, Schreieck, et al., 2019, p. 90). Accordingly, value co-creation among all ecosystem actors and the platform owner engaging in mediating and governing complementary activities is central to platform ecosystems. At the core of digital platform ecosystems is the digital platform, which is an extensible codebase to which partners may add complementary modules such as applications (De Reuver et al., 2018; Tiwana et al., 2010).

As indicated, partners play a crucial role in digital platform ecosystems. First, partners extend the platform's functionality and drive user-oriented innovation (Boudreau, 2010; Tavalaei & Cennamo, 2020). These activities center around the development of modular pieces of software to be added to the platform core as applications with partners acting as developers (De Reuver et al., 2018; Tiwana et al., 2010). The applications add value to the platform offering and often focus on product areas, where the platform owner lacks expertise or where market conditions prevent entry by the platform owner (Huang, Ceccagnoli, Forman, & Wu, 2009). Certain applications may reach "superstar" status, which in turn grants its developer additional power within the ecosystem (M. Li, Goh, & Cavusoglu, 2014; Srinivasan & Venkatramen, 2008). These developers wield greater power to negotiate terms and conditions with the platform owner than their peers (Valença, Alves, & Jansen, 2018). This has implications for ecosystem governance, as we will elaborate on in the next section. Second, partners engage in selling the platform to users, thus extending the reach and scale of the platform owner's sales teams. Partners also customize and implement the platform for users, acting as consulting partners (Wareham et al., 2014). Importantly, consulting partners intermediate in the platform-customer relationship, at least to some degree. Giving away control of this important relationship to partners again has important implications for the management of these partners. While most partners focus on one of the roles, some partners offer applications and extended consulting simultaneously. Furthermore, partners differentiate their offerings based on their expertise or market knowledge to provide valuable products and services to customers (Cenamor, 2021).

To manage their ecosystem of partners, platform owners create and enforce governance mechanisms (Tiwana et al., 2010; Wareham et al., 2014). Platform governance includes decision rights, access rights, and value capture (Halckenhaeusser, Foerderer, & Heinzl, 2020a; Tiwana, 2014). Decision rights, for instance, encompass aspects of interface design, the ownership of platform assets, or preferred user access (Schreieck, Wiesche, & Krcmar, 2016). Access rights concern the questions of who may participate in a platform ecosystem and the rights associated with a certain partner level. For instance, partner programs are being used to define the rules and metrics for partners to participate and engage with the ecosystem (Engert et al., 2020). Platform governance is also concerned with the modes of value capture for all ecosystem participants, including pricing schemes and billing processes (Schreieck & Wiesche, 2019). Partner managers cultivate the relationship between platforms and their partners to further develop and strengthen the connection and offer support. Hence, partner managers operationalize the overarching partner strategy of the platform by enforcing or bending governance rules (Foerderer, 2017; Huber et al., 2017). As partner managers have considerable autonomy regarding the allocation of their resources, they possess a great influence on the perception of platform governance by their partners (Benlian, Hilkert, & Hess, 2015; Hurni, Huber, Dibbern, & Krancher, 2020). In platform governance and thus partner management, several governance tensions occur, which need to be balanced for the ecosystem to thrive.

Governance Tensions and Information Capacity

The continuous operationalization of platform governance is associated with solving and balancing various *governance tensions* (Gawer & Henderson, 2007; Z. Li & Agarwal, 2017). Table 1 shows different governance tensions for platform owners in digital platform ecosystems.

Governance Tension & Description	Sources
Generativity vs. Stability More complementors result in more co-created value but also in a more unstable platform.	(Tilson, Lyytinen, & Sørensen, 2010; Wareham et al., 2014)
Freedom vs. Quality More freedom for complementors leads to greater generativity of the platform but also potential misuse of the freedom.	(Huber et al., 2017; Rickmann, Wenzel, & Fischbach, 2014; Schreieck & Wiesche, 2019)
Micro vs. Macro-Management Individual governance of complementors yields greater co-created value but higher costs.	(den Hartigh, Visscher, Tol, & Salas, 2013; Huber et al., 2017)
Competitive vs. Cooperative A competitive approach yields greater control over the platform but could scare complementors off from investing themselves.	(Eaton, Elaluf-Calderwood, Sørensen, & Yoo, 2015; Gawer & Cusumano, 2002; Parker et al., 2017)
Access vs. Control Greater access leads to increased innovations but a higher cost in coordinating them.	(Avila & Terzidis, 2016; Boudreau, 2010; Engert et al., 2020)

Table 1 Governance tensions for platforms owners in digital platform ecosystems

First, platform owners have to decide on the openness of their platform. That is, opening a platform to third-parties may result in increased generativity and thus co-created value. However, at the same time, opening the platform destabilizes the platform and tempers interactions as shown by Wessel, Thies, and Benlian (2017). Second, while a certain degree of openness increases the number of complementary products and services, the platform owner needs to find a balance between ensuring the quality of those complements and the freedom of complementors to innovate. Strict rules, like certification processes, may ensure the quality of complements, but come at the cost of stifling innovation (Huber et al., 2017; Song, Xue, Rai, & Zhang, 2018). Third, as partner managers are tasked with allocating their time and other resources to individual partners in a way to optimize ecosystem performance, they face the tension of choosing between micro and macro-management approaches. That is, partner managers need to decide where generic (macro) support, such as technical documentation or individual (micro) support like personal sessions is appropriate (Huber et al., 2017). Fourth, developing and implementing a partner strategy challenges platform owners to decide on striking the balance between competitive and collaborative approaches and which partners to support, for instance, in winning new customer deals (Foerderer, Kude, Mithas, & Heinzl, 2018; Gawer & Henderson, 2007). For example, the platform owner entering complementary markets or offering their consulting services to customers is usually perceived as a hostile strategy by complementors, which needs to be balanced with supportive measures (Foerderer et al., 2018; Halckenhaeusser, Foerderer, & Heinzl, 2020b). Finally, closely related to all prior governance tensions is the tension regarding the costs to govern the ecosystem. While great openness, generic rules, macro-management approaches, and unbalanced competition can be enacted with low efforts, strict rules and tighter control come at high governance costs (Avila & Terzidis, 2016; Boudreau, 2010).

To conclude, platform owners in digital platform ecosystems are required to create a partner strategy that balances governance tensions in many dimensions. Partner managers are at the interface to complementors and thus at the forefront in interpreting and operationalizing the overarching partner strategy (Huber et al., 2017). In that process, they face many tradeoffs, which require the platform to establish an *information capacity*, allowing them to make decisions in these complex environments (Wang, 2021). Information capacity “refers to the capabilities to inform, that is, to collect, process, store, and distribute information” (Wang, 2021, p. 25). These capabilities are at the core of information systems. Therefore, this study employs a DSR approach concerning a tool to enable and support partner managers of enterprise software platforms to make more informed decisions based on metrics and KPIs.

Research Approach

Applying DSR results in the creation of a purposeful IT artifact, which addresses an important organizational problem (Hevner et al., 2004). According to Gregor and Hevner (2013), artifacts involve decision support systems, modeling tools, governance strategies, methods for IS evaluation, and IS change interventions. Following the guidelines for DSR research as proposed by Gregor and Hevner (2013) and Hevner et al. (2004), we develop an innovative artifact for an unresolved problem. Table 2 provides an overview of our practice-oriented research approach based on Peffers et al. (2007) during our first design cycle.

Activity	Description
(1) Identify Problem & Motivation	Identify the problem and highlight importance (see Introduction and DSR Step 1)
(2) Define Solution Objectives	Conduct nine interviews with partner managers to derive requirements and determine relevant design principles (see DSR Step 2)
(3) Design & Develop	Implement the artifact to support decision-making by partner management in digital platform ecosystems (see DSR Step 3)
(4) Demonstrate	Use the artifact during a simulation in its context (see DSR Step 4)
(5) Evaluate	Evaluate the utility and effectiveness of the artifact and specify requirements for the next DSR iteration (see DSR Step 4)
(6) Communicate	Publish approach and artifact to receive scholarly and practical feedback (the current paper)

Table 2 Applied DSR approach (Peffers et al. (2007))

During the first stage, we identify and formulate the problem and our motivation, presented in the first two sections of this paper. Second, we conduct semi-structured interviews with partner managers from three digital platform ecosystems (Company A, Company B, and Company C) in the enterprise software industry. Table 3 provides an overview of the interview partners, their respective roles, interview length, and brief company descriptions.

ID	Case	Interviewee Position	Length
IP1	Company A	Regional partner manager	47 min
IP2	Company A	Regional partner manager	40 min
IP3	Company A	Global analytics software engineer	40 min
IP4	Company B	Vice president partner management region	43 min
IP5	Company B	Partner management - engagement	60 min
IP6	Company B	Partner management - technology	66 min
IP7	Company C	Manager strategic partnerships	45 min
IP8	Company C	Senior partner manager	52 min
IP9	Company C	Director regional partner management	53 min
Company A is a German platform provider focusing on the analysis and automation of business processes via their enterprise software. It operates a global partner ecosystem with more than 100 partners in app development and consulting.			
Company B is an American platform provider offering customer relationship management software for businesses. It builds on a global partner ecosystem of development and consulting partners with more than 3000 partners.			
Company C is an American platform provider offering process and workflow management software for businesses. It manages a global ecosystem of technology and consulting partners with more than 1000 partners.			

Table 3 Overview of interview partners

Based on the insights from the interviews, we define the objectives and the requirements of the proposed artifact, more precisely a software-based tool used for supporting partner managers' decisions while operationalizing the platform partner strategy based on KPIs. We analyze the interview data using coding procedures including open, axial, and selective coding (Glaser & Strauss, 1967) to derive the partner manager tasks and tool requirements explicitly and implicitly stated by interviewees. For instance, IP4 stated: *"How satisfied were the customers with the implementation? How actively do the partners certify themselves? [..] How many opportunities come in through this partner? And then of* *course you can make a ranking, that is, of course, something that would be very helpful. Also, when it comes to finding the right partner or the right partner for a certain project."* From the statement, we derived Requirements R1 and R2 (see Table 4), concerning the evaluation of partners via KPIs and the possibility to rank them. Moreover, we determine the design principles for the artifact. In stage three, we develop and implement the artifact for decision support. Fourth, we demonstrate the artifact using a simulation (Peffers et al., 2012; Venable et al., 2012). Hence, this iteration comprises alpha and beta testing and a simulation to demonstrate that the proposed tool can be used to solve practical problems (Hevner et al., 2004). During stage five, we evaluate the artifact and derive conclusions regarding its utility and effectiveness. In particular, we discuss the tool usability and the results of the simulation, and options for improvement in planned future iterations. Stage six concludes our first DSR iteration by providing the academic community with our insights and by making the artifact available to the community for further contributions. Access to the GitLab repository can be requested from the authors.

Results

This section describes the results of our data analysis, comprising partner management tasks and requirements. Further, it specifies the derived design principles for the artifact, elaborates on the implemented artifact, and demonstrates the implemented software-based tool to enable partner managers in their key tasks via a simulation.

DSR Step 2: Partner Management Tasks, Requirements, and Design Principles

During our study, we aimed to provide a working prototype, which facilitates the management of a broad partner network. For this first design iteration we, therefore, focused on the core functionalities of the tool. To provide a highly relevant and valuable tool for practitioners, we derived the requirements from expert interviews with partner managers managing a broad partner network. This approach ensured a deep understanding of partners' value contributions, the key activities of partner managers, and the associated challenges. First, we classified **partner management tasks** into four main subsections, which need to be supported by the proposed tool: (1) individual partner management, (2) comparison and ranking of partners and (3) the management of the partner network, and (4) the management of partner managers by e.g., the head of partner management in a certain region. This classification is illustrated in Figure 1. The four basic tasks build the core structure and design choice of the proposed artifact as presented in DSR Step 3.

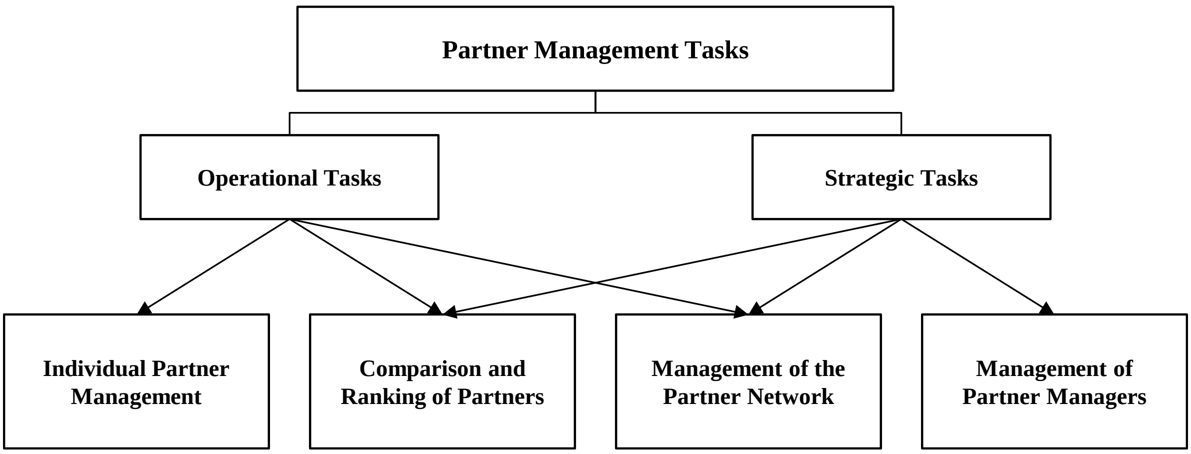

Figure 1 Classification of partner management tasks

Second, by analyzing and identifying the most pressing needs and challenges of partner management, we selected and prioritized seven **requirements** which are listed in Table 4. Since we first aim to provide support for partner managers on an operational level, we selected requirements for tasks (1), (2), and (3). The higher-order task (4) will be considered in future iterations.

Requirement Description [R#]	Interview Sources
R1: Analyze and evaluate partners based on key KPIs (e.g., customer satisfaction or marketing activities).	**IP 1, 2, 3, 4, 5, 6, 7, 8, 9**
R2: Offer features to compare and rank partners based on KPIs.	**IP 1, 2, 3, 7, 9**
R3: Make relevant information easily accessible by providing visual guidance.	**IP 2, 3, 7**
R4: Provide an aggregated view of the development of partner KPIs.	**IP 1, 2**
R5: Enable filtering and sorting of partners based on different categories (e.g., KPIs or primary market).	**IP 1, 2, 3**
R6: Offer prediction capabilities on the development of partners.	**IP 1, 2, 3**
R7: Options for personal customization by partner managers.	**IP 3**

Table 4 Requirements identified and selected for the tool prototype in the first iteration

During the DSR approach, the research team then deduced **design principles (DPs)** for all requirements. The DPs guided us through the creation of the artifact and link requirements to concrete implementations. We aimed to create DPs, which matched the requirements closely while being actionable and comprehensive for external parties. The DPs and more detailed descriptions thereof are presented in Table 5.

Req.	Design Principle (DP)	Description
R1	Show KPI tiles for each partner in absolute and relative numbers	Offers various options for in-depth analysis of partner performance.
R2	Include comparison views and graphs.	Both on the individual and the collective partner level.
R3	Utilize graphical, numerical, and tabular presentations.	Provide multiple data presentations for extensive analysis options.
R4	KPIs are provided in their aggregated form.	Enables the analysis of the overall performance of the partner network
R5	Individual filters can be set and combined to sort partners according to different aspects.	Enables comparison on a selection of partners and root cause analyses of performance differences.
R6	Prediction of the development of partners' performance based on historic data utilizing a linear regression model.	Support partner managers to detect deviations from goals as soon as possible.
R7	Users can customize displayed analyses and information on selected partners.	The user can save important partners to the start page, and select/deselect analyses.

Table 5 Design principles to fulfill identified requirements for the tool prototype

DSR Step 3: Design & Development of the Tool Prototype

The data yielded a broad range of partner management activities, which we grouped into the four tasks of partner management in DSR Step 2. Based on those tasks the research team opted for a dashboard-centric tool. That choice is supported by the interviewees:

> *So, what I would love is a dashboard where I could monitor individual partner's progress along with more metrics than just revenue and sourced opportunities. Things like a senior stakeholder, buy-in, number of certifications, marketing activity. [..] If you have all that stuff in place, you will win deals essentially.* (IP2)

The following technology stack was chosen to address the requirements and implement the prototype: Docker for Containerization, Angular Material and Node.js for the application, MongoDB for the database, and Nginx as a reverse proxy. The tool's hierarchical logic corresponds to the main activities of partner management (1) to (4), which are included in the navigation bar on the left of Figure 2. Partner management task (2), comparison, and ranking functionalities are included in the "Partners" view.

On starting the tool, the initial view is the personal dashboard, consisting of a customizable overview of the partner network and its development. It allows the partner manager to get a summary of the most important partners, the overall performance of the partner network, and the status of the partner levels. Important KPIs, such as customer satisfaction and the annual contract value are presented graphically as line and bar charts. Moreover, users can save 'favorite' partners to their dashboard for closer monitoring.

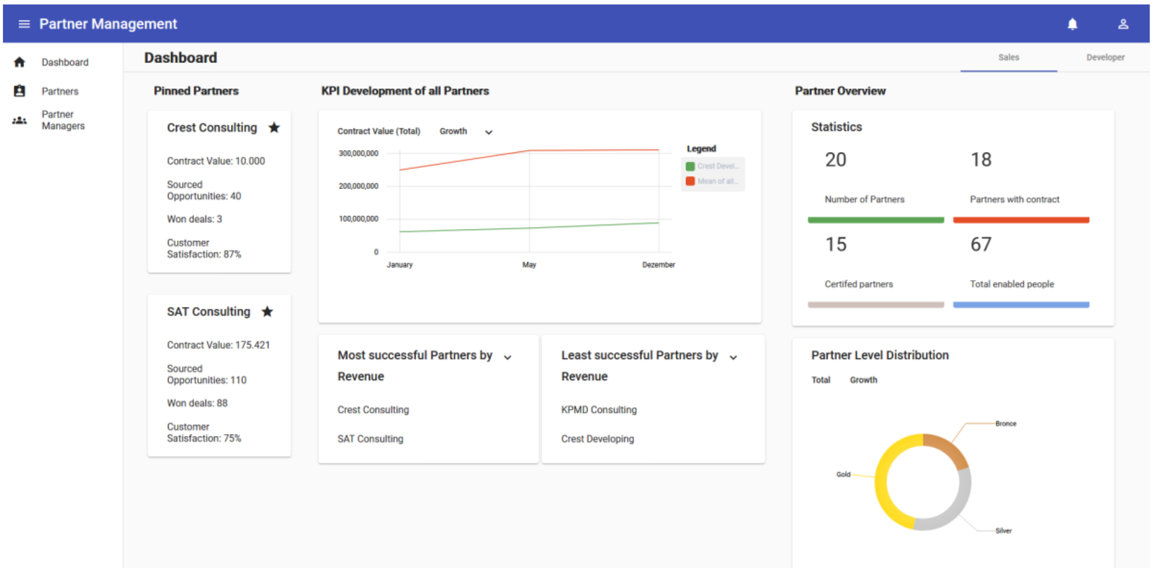

Figure 2 Starting view of the tool prototype for partner managers

After the first iteration, the tool further provides specialized views to support partner managers in their main operational tasks of managing individual partners (1) and their metric-based evaluation (2) and managing the partner network (3).

In the area of individual partner management, assistance is provided through several areas. First, in the upper left corner, general information like the partner's name or contact details is displayed. Once more, relevant KPIs are highlighted. In the next tile, those KPIs are also presented graphically allowing immediate detection of deviations. To rank the partner, the comparison tile shows the performance against the partner network. Since partner programs are a vital part of platform ecosystems and usually consist of certain requirements for a partner to meet (Engert et al., 2020), our tool dedicates an area for monitoring the compliance of partners with their respective programs. Lastly, the forecasting function predicts whether the partner will meet their revenue target or other KPIs based on linear regression. To equip the partner manager with an indication of how the reliable the prediction is, the r^2 coefficient is given. To customize the tool to their needs, partner managers can, for instance, activate or deactivate the presented analyses. The comparison and ranking functionalities (2) are firstly integrated into the individual partner view as presented above and additionally facilitated through the tabular view of partners. Here, partner managers can apply sorting and filtering options or search for specific partners to *"find the right partner for a certain project"* [IP3]. We designed this view to be as flexible as possible in providing partner managers support in various areas and tasks even in unforeseen situations.

DSR Step 4: Demonstration & Evaluation

In this section, we demonstrate the tool and evaluate its quality, utility, and efficacy. The quality comprises the design of the implementation, which can be assessed via the selected technological architecture and its fit for the purpose and related performance (Hevner et al., 2004). Utility concerns the applicability to the designated business environment (Gregor & Hevner, 2013). Lastly, the tool's ability to solve the identified problems is referred to as the efficacy of the artifact (Peffers et al., 2007). Hevner et al. (2004) extracted five commonly applied methodologies for the evaluation of artifacts during DSR. These include observational (e.g., case studies), analytical (e.g., analyses of the architecture), experimental (e.g., simulations) or descriptive (e.g., scenarios) methods, and formal testing. The selection of an appropriate evaluation method primarily depends on the artifact and its environment. To ensure a thorough evaluation, we opted for a combination of the described methodologies. We integrate analytical, experimental, and descriptive methods. To evaluate the artifact quality, which refers to the design of the architecture and appearance of the artifact, we analyze the artifact's architectural fit into the infrastructure of its prototypical technological and business environment. Additionally, to evaluate the tool's utility and efficacy, we construct a scenario that integrates different areas of partner management and simulate it in our tool using artificial data. We thus showcase the support our tool can give to partner governance in a complex situation.

First, to analyze the fit of the chosen **architecture** into the applicable technological and business environment, we identify current trends and developments in software engineering. Over many years, the adoption of agile development methods has led towards a focus on user needs and resulted in shorter release cycles (Boehm, 2006; Hemon, Lyonnet, Rowe, & Fitzgerald, 2020). Furthermore, microservice architectures have become popular in many organizations, which has increased the scalability, reliability, and maintainability of the resulting software. Since microservices closely correlate with business functions, organizations highly value this architectural style and adopt it frequently (Alshuqayran, Ali, & Evans, 2016). Thus, we adopted a microservice architecture. Since the use of software in organizations is continuously growing and changing, they struggle to align the diverse IT landscapes with their business operations (Kleehaus & Matthes, 2019). DevOps approaches are used to mitigate these issues by automating the setup process, delivery, and documentation through scripting rather than manual installation guides (Hemon et al., 2020). For these reasons, the artifact is built on the popular software Docker (Henkel, Bird, Lahiri, & Reps, 2020). Lastly, a growing number of commercial off-the-shelf software packages is accessed through web browsers. Web-based applications allow the collaboration of teams across location, time, and organizational boundaries. This is why the presented artifact is accessible through a web-app. To summarize, the resulting architecture of the artifact builds on up-to-date features such as microservices, DevOps support, and web-access, which gives it the quality to be easily integrated into existing enterprise architectures.

Second, we use a **scenario-based simulation** to demonstrate and evaluate the utility and efficacy of the tool prototype. Based on a predefined scenario from partner management, we start the simulation by using the tool from the perspective of a partner manager. The scenario comprises the initial detection and analysis of irregularities for individual partners, which might affect the entire partner network. Hence, this simulation provides the first evidence for the utility of the tool in supporting partner managers in complex situations. The scenario is introduced in the next section.

SoftCorp is an international platform firm providing enterprise software, which utilizes sales and implementation partners in various European countries to sell their software. SoftCorp governs its partners through a partner program, which sets the partnership rules including the expected KPIs, and which is enacted by partner managers. Individual partner managers oversee multiple partners in different countries. To govern multiple partners more efficiently, the company utilizes the presented artifact. The core responsibility of partner managers is monitoring the partners' sales activities and supporting them in generating sales leads and closing deals. It is March 2020 and Sara is a partner manager for SoftCorp, in charge of partners in France and Italy.

As usual, on a Monday, Sara views the aggregated dashboards of all her assigned partners in her partner management tool. The individual views show that the total number of signed deals by her partners last month was as expected. She now wants to use the tool to analyze whether the upcoming month will be as successful as the last one. Sara, therefore, checks the development of the newly sourced opportunities and generated leads, which are essential for closing deals. Due to the graphical presentation provided by the tool, she instantly detects a small decrease. To further validate this concerning development, she uses the tool to check the growth rate of those metrics in greater detail. Both graphs show a significant negative predicted growth rate. Thus, her partners have acquired fewer potential customers than in the previous months. Since potential customers are essential for closed deals in the next few months, Sara tries to find the causes of this trend. She then compares her most important Italian and French partners, which she both saved to her starting page. She sees that the French partner is performing similarly to previous months but the Italian partner's performance is declining. Checking on the details page of the Italian partner, she detects severe performance declines in all the other KPIs, including customer training and the certification of partner employees. To determine whether the development is partner-specific or generally affecting the partner network, she tries to find a common attribute connecting all poorly performing partners. She, therefore, utilizes the tools tabular view as it allows more flexible analyses. By filtering and sorting, she quickly notices that all Italian partners are currently performing worse. Conducting further research, Sara learns that Covid-19 has started to impact the Italian economy and driven down customers' investments, slowing the software sales of SoftCorp's sales partners. Summarizing her insights in the notes tab of the tool, Sara reports to her senior manager, who utilizes the information about the Italian market and prepares a response strategy for all partner managers within the region.

The simulation shows that the proposed tool prototype supports partner managers in all their operational tasks, and thus has great utility. That is, by providing partner managers with access to information on individual partners, the tool enables partner managers to focus on individual relationships. Also, ranking and comparing partners based on KPIs as well as viewing the network of partners helps partner managers with their tasks quickly and efficiently. We conclude, therefore, that the artifact is efficacious for partner managers.

Discussion and Conclusion

In this paper, we designed and evaluated a software-based tool to support partner managers in creating and operationalizing the partner strategies of digital platform providers following a DSR approach. That is, through the IT-artifact, we contribute to research on digital platform ecosystems and the tools needed for their management. It enables partner managers to detect and react on time to uncommon developments with complementors based on a firm knowledge of their causes. To determine requirements for such a tool, we conducted nine interviews with partner managers from three digital platform ecosystems in the enterprise software domain. During our first DSR cycle, we implemented seven requirements and evaluated the resulting prototype based on an analysis of its architectural design and a scenario-based simulation. The proposed tool supports metric-based approaches to the design and governance of digital platform ecosystems from a partner management perspective and initiates the scholarly discussion on decision support systems in digital platform ecosystems. Thus, our work has implications for research on platform design and governance and the need for information from a platform owner perspective. In particular, we highlight the importance of metric-based approaches to governance decision-making and the operationalization of partner strategies. Practitioners benefit from an open-source tool prototype, which will be refined and tested in future iterations.

The management of digital platform ecosystems is an ongoing challenge for the platform owner. Partner managers are at the interface of the platform, shaping and implementing the platform partner strategy when governing complementors. As the review of prior literature showed, partner managers face several interrelated tensions, ranging from balancing quality to mitigating aspects of intraplatform competition (Eaton et al., 2015; Huber et al., 2017). To that end, a platform owner's information capacity allows them to make informed governance decisions (Wang, 2021). Following that stance, our proposed IT-based tool advances platform owners' information capacity by providing relevant information to partner managers. Therefore, our contribution emphasizes the role of IT as the backbone of a platform owner's information capacity (Wang, 2021) and initiates the discussion on decision support systems in digital platform ecosystems. As indicated in the evaluation of the artifact, it acts as a boundary object (cf. Star (2010)) between partner managers and senior partner management, allowing them to assess the situation and discuss and derive their actions accordingly.

The identified tasks of partner management detail the findings of Avila and Terzidis (2016) and provide the basis for the tool design and inform researchers on the scope of partner managers' tasks to be included in future work on platform governance. Further, the requirements formulated from the interview data yield additional insights into the tasks and needs of the operational level of platform governance. While prior work has mostly focused on the assessment of entire ecosystems and networks concerning, for instance, ecosystem health (e.g., Jansen (2014)), our results stress the need for more detailed metrics and KPIs. Advancing the understanding of governance on the operational level will allow research and practice to develop and evaluate different KPIs for digital platform ecosystems.

Moreover, the empirical understanding of the needs and uses of information in partner management presented in the current study provides the basis for addressing the overarching governance challenges depicted in the theoretical background. That is, building on the information provided by the proposed artifact, partner managers may track individual complementors to make better decisions on which partners to focus their resources, balancing the micro vs. macro-management tension (den Hartigh et al., 2013; Huber et al., 2017). Similarly, information from the dashboard related to the partner ecosystem can be used by partner managers to address tensions such as freedom vs. quality (via monitoring customer satisfaction) or access vs. control (via monitoring the number of new partners or applications). However, more research is necessary to link the tensions identified in this work with relevant metrics and KPIs to provide best practices for partner managers. From these insights, additional KPIs can then be added to the dashboard. Importantly, the role of metrics and KPIs in managing the competitive vs. collaborative and the generativity vs. stability tensions remains unclear.

Although this paper presents the results of our first DSR iteration, it is subject to certain limitations. To date, only seven requirements have been realized, as we focused on the core functionalities of the tool. Currently, the task of managing partner managers by senior partner management has not been implemented and will be considered in our next design iteration. Furthermore, the evaluation of the tool prototype is demonstrated through a scenario-based simulation. Even though this is a valid evaluation method (Peffers et al., 2012), additional iterations and more user feedback are required. Applying the tool based on data from a platform company will yield additional insights regarding its usefulness in partner management and its impact on decision-making quality. Hence, based on further user feedback and insights provided by the scientific community, we are planning to expand the functionality of the tool in future iterations.

References

Alshuqayran, N., Ali, N., & Evans, R. (2016). A Systematic Mapping Study in Microservice Architecture. In *2016 IEEE 9th International Conference on Service-Oriented Computing and Applications: Soca 2016 : Proceedings : 4-6 November 2016, Macau, China* (pp. 44–51). Piscataway, NJ: IEEE. https://doi.org/10.1109/SOCA.2016.15

Avila, A., & Terzidis, O. (2016). Management of Partner Ecosystems in the Enterprise Software Industry. In *Eighth International Workshop on Software Ecosystems co-located with Tenth International Conference on Information Systems (ICIS 2016), Dublin, Ireland, 2016.: IWSECO 2016*.

Benlian, A., Hilkert, D., & Hess, T. (2015). How open is this platform? The meaning and measurement of platform openness from the complementors' perspective. *Journal of Information Technology*, *30*(3), 209–228. https://doi.org/10.1057/jit.2015.6

Blasco-Arcas, L., Alexander, M., Sörhammar, D., Jonas, J. M., Raithel, S., & Chen, T. (2020). Organizing actor Engagement: A platform perspective. *Journal of Business Research*, *118*, 74–85. https://doi.org/10.1016/j.jbusres.2020.06.050

Boehm, B. (2006). A view of 20th and 21st century software engineering. In L. J. Osterweil (Ed.), *Proceedings of the 28th international conference on Software engineering* (p. 12). New York, NY: ACM. https://doi.org/10.1145/1134285.1134288

Boudreau, K. J. (2010). Open platform strategies and innovation: Granting access vs. devolving control. *Management Science*, *56*(10), 1849–1872. https://doi.org/10.1287/mnsc.1100.1215

Cenamor, J. (2021). Complementor competitive advantage: A framework for strategic decisions. *Journal of Business Research*, *122*, 335–343. https://doi.org/10.1016/j.jbusres.2020.09.016

De Reuver, M., Sørensen, C., & Basole, R. C. (2018). The Digital Platform: A Research Agenda. *Journal of Information Technology*, *33*(2), 124–135. https://doi.org/10.1057/s41265-016-0033-3

Den Hartigh, E., Visscher, W., Tol, M., & Salas, A. J. (2013). Measuring the health of a business ecosystem. In Slinger Jansen, M. A. Cusumano, & S. Brinkkemper (Eds.), *Software Ecosystems: Analyzing and Managing Business Networks in the Software Industry* (pp. 221–246). Edward Elgar Publishing. Retrieved from https://www.elgaronline.com/view/edcoll/9781781955628/9781781955628.00020.xml

Eaton, B., Elaluf-Calderwood, S., Sørensen, C., & Yoo, Y. (2015). Distributed tuning of boundary resources: The case of Apple’s iOS service system. *MIS Quarterly*, *39*(1), 217–243. https://doi.org/10.25300/misq/2015/39.1.10

Engert, M., Hein, A., & Krcmar, H. (2020). Partner Programs and Complementor Assessment in Platform Ecosystems: A Multiple-Case Study. In *Twenty-Sixth Americas Conference on Information Systems: AMCIS 2020,* A Virtual Conference (Due to global COVID-19 situation).

Foerderer, J. (2017). Relational third-party governance: Evidence from Apple's World Wide Developer Conference. In *Platform Strategy Research Symposium 2017,* Boston, MA, United States of America.

Foerderer, J., Kude, T., Mithas, S., & Heinzl, A. (2018). Does Platform Owner’s Entry Crowd Out Innovation? Evidence from Google Photos. *Information Systems Research*, *29*(2), 444–460. https://doi.org/10.1287/isre.2018.0787

Fotrousi, F., Fricker, S. A., Fiedler, M., & Le-Gall, F. (2014). Kpis for Software Ecosystems: A Systematic Mapping Study. In C. Lassenius & K. Smolander (Chairs), *ICSOB 2014*, Paphos, Cyprus.

Gawer, A., & Cusumano, M. A. (2002). *Platform leadership: How Intel, Microsoft, and Cisco drive industry innovation*. Boston, Massachusetts: Harvard Business School Press.

Gawer, A., & Henderson, R. (2007). Platform owner entry and innovation in complementary markets: Evidence from Intel. *Journal of Economics and Management Strategy*, *16*(1), 1–34. https://doi.org/10.1111/j.1530-9134.2007.00130.x

Glaser, B. G., & Strauss, A. L. (1967). *The discovery of grounded theory: Strategies for qualitative research*. New York, NY, United States of America: Aldine.

Graça, P., & Camarinha-Matos, L. M. (2017). Performance indicators for collaborative business ecosystems — Literature review and trends. *Technological Forecasting and Social Change*, *116*, 237–255. https://doi.org/10.1016/j.techfore.2016.10.012

Gregor, S., & Hevner, A. R. (2013). Positioning and Presenting Design Science Research for Maximum Impact. *MIS Quarterly*, *37*(2), 337–355. https://doi.org/10.25300/MISQ/2013/37.2.01

Halckenhaeusser, A., Foerderer, J., & Heinzl, A. (2020a). Platform Governance Mechanisms: An Integrated Literature Review and Research Directions. In *Twenty-Eighth European Conference on Information Systems: ECIS 2020,* A Digital Conference.

Halckenhaeusser, A., Foerderer, J., & Heinzl, A. (2020b). Wolf in a Sheep’s Clothing: When Do Complementors Face Competition With Platform Owners? In *Forty-First International Conference on Information Systems: ICIS 2020,* A digital conference (due to Covid-19).

Hein, A., Schreieck, M., Riasanow, T., Setzke, D. S., Wiesche, M., Böhm, M., & Krcmar, H. (2019). Digital platform ecosystems. *Electronic Markets, 30*(1), 87–98. https://doi.org/10.1007/s12525-019-00377-4

Hein, A., Weking, J., Schreieck, M., Wiesche, M., Böhm, M., & Krcmar, H. (2019). Value co-creation practices in business-to-business platform ecosystems. *Electronic Markets*, *29*(3), 503–518. https://doi.org/10.1007/s12525-019-00337-y

Hemon, A., Lyonnet, B., Rowe, F., & Fitzgerald, B. (2020). From Agile to DevOps: Smart Skills and Collaborations. *Information Systems Frontiers*, *22*(4), 927–945. https://doi.org/10.1007/s10796-019-09905-1

Henkel, J., Bird, C., Lahiri, S. K., & Reps, T. (2020). Learning from, understanding, and supporting DevOps artifacts for docker. In G. Rothermel (Ed.), *ACM Digital Library, Proceedings of the ACM/IEEE 42nd International Conference on Software Engineering* (pp. 38–49). New York,NY,United States: Association for Computing Machinery. https://doi.org/10.1145/3377811.3380406

Hevner, A. R., March, S. T., Park, J., & Ram, S. (2004). Design Science in Information Systems Research. *MIS Quarterly*, *28*(1), 75–105.

Huang, P., Ceccagnoli, M., Forman, C., & Wu, D. J. (2009). When Do ISVs Join a Platform Ecosystem? Evidence from the Enterprise Software Industry. In *Thirtieth International Conference on Information Systems: ICIS 2009,* Phoenix, AZ, United States of America.

Huber, T. L., Kude, T., & Dibbern, J. (2017). Governance practices in platform ecosystems: Navigating tensions between cocreated value and governance costs. *Information Systems Research*, *28*(3), 563–584. https://doi.org/10.1287/isre.2017.0701

Hurni, T., Huber, T. L., Dibbern, J., & Krancher, O. (2020). Complementor dedication in platform ecosystems: rule adequacy and the moderating role of flexible and benevolent practices. *European Journal of Information Systems*, 1–24. https://doi.org/10.1080/0960085X.2020.1779621

Jansen, S. [Slinger] (2014). Measuring the health of open source software ecosystems: Beyond the scope of project health. *Information and Software Technology*, *56*(11), 1508–1519. https://doi.org/10.1016/j.infsof.2014.04.006

Kleehaus, M., & Matthes, F. (2019). Challenges in Documenting Microservice-Based IT Landscape: A Survey from an Enterprise Architecture Management Perspective. In *2019 IEEE 23rd International Enterprise Distributed Object Computing Conference: EDOC 2019 : proceedings : Paris, France, 28-31 October 2019* (pp. 11–20). Los Alamitos, CA: IEEE Computer Society. https://doi.org/10.1109/EDOC.2019.00012

Li, M., Goh, K.-Y., & Cavusoglu, H. (2014). Investigating Developers' Entry to Mobile App Platforms: A Network Externality View. In *Twenty-Second European Conference on Information Systems: ECIS 2014,* Tel Aviv, Israel.

Li, Z., & Agarwal, A. (2017). Platform integration and demand spillovers in complementary markets: Evidence from facebook's integration of instagram. *Management Science*, *63*(10), 3438–3458. https://doi.org/10.1287/mnsc.2016.2502

Parker, G. G., van Alstyne, M. W., & Jiang, X. (2017). Platform ecosystems: How developers invert the firm. *MIS Quarterly*, *41*(1), 255–266.

Peffers, K., Rothenberger, M., Tuunanen, T., & Vaezi, R. (2012). Design Science Research Evaluation. In D. Hutchison, T. Kanade, J. Kittler, J. M. Kleinberg, F. Mattern, J. C. Mitchell, . . . B. Kuechler (Eds.), *Lecture Notes in Computer Science. Design Science Research in Information Systems. Advances in Theory and Practice*. Berlin, Heidelberg: Springer Berlin Heidelberg.

Peffers, K., Tuunanen, T., Rothenberger, M. A., & Chatterjee, S. (2007). A Design Science Research Methodology for Information Systems Research. *Journal of Management Information Systems*, *24*(3), 45–77. https://doi.org/10.2753/MIS0742-1222240302

Plakidas, K., Schall, D., & Zdun, U. (2017). Evolution of the R software ecosystem: Metrics, relationships, and their impact on qualities. *Journal of Systems and Software*, *132*, 119–146. https://doi.org/10.1016/j.jss.2017.06.095

Rickmann, T., Wenzel, S., & Fischbach, K. (2014). Software Ecosystem Orchestration: The Perspective of Complementors. In *Twentieth Americas Conference on Information Systems: AMCIS 2014*, Savannah, GA, United States of America.

Schreieck, M., & Wiesche, M. (2019). Value Cocreation and Value Capture in Digital Platforms. *Academy of Management Proceedings*, *2019*(1). https://doi.org/10.5465/AMBPP.2019.10450abstract

Schreieck, M., Wiesche, M., & Krcmar, H. (2016). Design and Governance of Platform Ecosystems – Key Concepts and Issues for Future Research. In *Twenty-Fourth European Conference on Information Systems: ECIS 2016*, Istanbul, Turkey.

Senyo, P. K., Liu, K., & Effah, J. (2019). Digital business ecosystem: Literature review and a framework for future research. *International Journal of Information Management*, *47*, 52–64. https://doi.org/10.1016/j.ijinfomgt.2019.01.002

Song, P., Xue, L., Rai, A., & Zhang, C. (2018). The ecosystem of software platform: A study of asymmetric cross-side network effects and platform governance. *MIS Quarterly*, *42*(1), 121–142. https://doi.org/10.25300/MISQ/2018/13737

Srinivasan, A., & Venkatramen, N. (2008). The Role of Indirect Network Effects in Explaining Platform Dominance in the Video Game Industry (2002-2006): A Network Perspective. In *Twenty-Ninth International Conference on Information Systems: ICIS 2008*, Paris, France.

Tavalaei, M. M., & Cennamo, C. (2020). In search of complementarities within and across platform ecosystems: Complementors' relative standing and performance in mobile apps ecosystems. *Long Range Planning*, 101994. https://doi.org/10.1016/j.lrp.2020.101994

Tilson, D., Lyytinen, K., & Sørensen, C. (2010). Digital infrastructures: The missing IS research agenda. *Information Systems Research*, *21*(4), 748–759. https://doi.org/10.1287/isre.1100.0318

Tiwana, A. (2014). *Platform ecosystems: Aligning architecture, governance, and strategy*. Amsterdam et al., Netherlands et al.: Morgan Kaufmann.

Tiwana, A., Konsynski, B., & Bush, A. A. (2010). Platform evolution: Coevolution of platform architecture, governance, and environmental dynamics. *Information Systems Research*, *21*(4), 675–687. https://doi.org/10.1287/isre.1100.0323

Valença, G., Alves, C., & Jansen, S. [S.] (2018). Strategies for managing power relationships in software ecosystems. *Journal of Systems and Software*, *144*, 478–500. https://doi.org/10.1016/j.jss.2018.07.036

Venable, J., Pries-Heje, J., & Baskerville, R. (2012). A Comprehensive Framework for Evaluation in Design Science Research. In D. Hutchison, T. Kanade, J. Kittler, J. M. Kleinberg, F. Mattern, J. C. Mitchell, . . . B. Kuechler (Eds.), *Lecture Notes in Computer Science. Design Science Research in Information Systems. Advances in Theory and Practice* (Vol. 7286, pp. 423–438). Berlin, Heidelberg: Springer Berlin Heidelberg. https://doi.org/10.1007/978-3-642-29863-9_31

Wang, P. (2021). Connecting the Parts with the Whole: Toward an Information Ecology Theory of Digital Innovation Ecosystems. *MIS Quarterly*, *45*(1b), 397–422. https://doi.org/10.25300/MISQ/2021/15864

Wareham, J., Fox, P. B., & Giner, J. (2014). Technology ecosystem governance. *Organization Science*, *25*(4), 1195–1215. https://doi.org/10.1287/orsc.2014.0895

Wessel, M., Thies, F., & Benlian, A. (2017). Opening the floodgates: The implications of increasing platform openness in crowdfunding. *Journal of Information Technology*, *32*(4), 344–360. https://doi.org/10.1057/s41265-017-0040-z

Yoffie, D. B., & Kwak, M. (2006). With Friends Like These: The Art of Managing Complementors. *Harvard Business Review*, *84*(9), 88–98. Retrieved from https://www.ncbi.nlm.nih.gov/pubmed/16967623