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

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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 Word-Press 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

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

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

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

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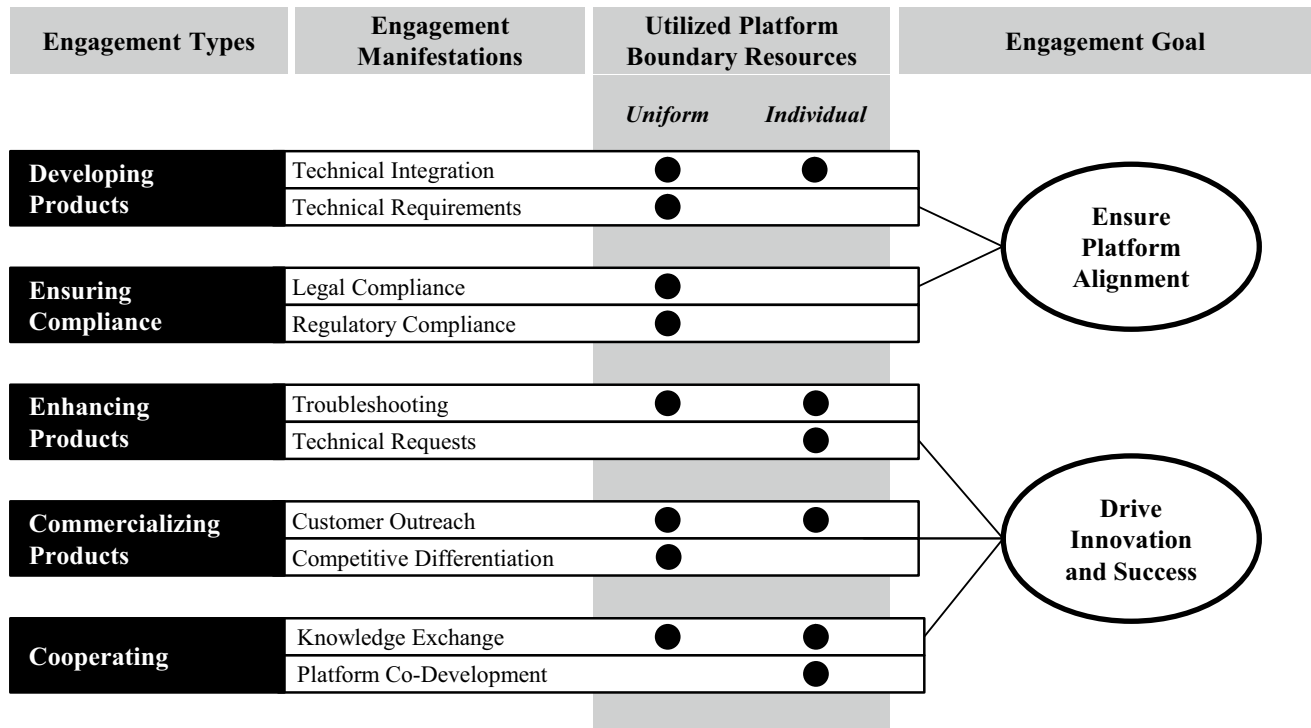
Fig. 1 Overview of complementor engagement and utilized platform boundary resources

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 inter-platform 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)

Declarations

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

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