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# Strategic openness: Category variety, boundary resources, and exclusive content as drivers of complementor participation

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## Abstract

This paper analyzes strategies for platform owners to increase complementor participation on their platform. Specifically, it draws on open innovation (OI) to theorize the impact of three drivers of complementor participation, namely category variety offered on the platform, the extent of boundary resources provided to facilitate complementary innovation, and exclusivity of content offerings. We hypothesize that higher levels of each of these drivers increase the platform's attractiveness to future complementors and thereby increase complementor participation. Based on negative binomial fixed-effects regressions in the context of video game consoles, we show that category variety has no effect on future complementor participation, while boundary resources and exclusive content do. The results have implications for the orchestration of platform ecosystems.

**Keywords** Platform · Ecosystem · Complementor participation · Open innovation · Boundary resources

**JEL Classification** L86 · M15 · O32 · L22 · D22 · C23

## Introduction

For innovation platforms (Hein et al., 2020) to thrive, how to attract complementors is a central strategy concern (McIntyre & Srinivasan, 2017). The importance of complementors in platform-based ecosystems is well-known (Boudreau, 2010), primarily as they create indirect network effects (Katz & Shapiro, 1985). When choosing a platform (e.g., game console), users often consider the availability of complementary offerings (e.g., number of games) next to the platform's

characteristics (e.g., quality of the console hardware) (Rietveld & Schilling, 2021). Yet, recent work shows that complementors (e.g., game creators) are less plentiful than often assumed (McGowan & Hienerth, 2022). Hence, strategies to attract complementors are important for platform owners.

Previous research has studied drivers and inhibitors of complementor participation (Broekhuizen et al., 2021; Engert et al., 2023). Early studies primarily give insights into initial adoption decisions at platform launch (O'Mahony & Karp, 2022), for instance focusing on complementor participation in terms of the famous chicken-and-egg problem (Caillaud & Jullien, 2003) or dynamics around the critical mass of participants (Evans & Schmalensee, 2010). More recently, studies have shifted focus to the continuous participation of complementors. Fang et al. (2021), for instance, show that temporary gatherings promote platform adoption by complementors. Heimburg et al. (2024) demonstrate how complementors' perception of power affect generative contributions. However, most of these studies focus on single drivers, and studies that take a broader perspective—such as Engert et al. (2023), who examine how platform resources and rules, the platform's and other complementors' value propositions, platform agents, and customer needs drive complementor participation—remain rare.

While prior studies have identified several drivers of complementor participation, we still lack an integrated

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theoretical lens that explains *how* platform design features facilitate and encourage external innovation by complementors. We propose open innovation (OI) as such a lens to understand how firms can facilitate and encourage external innovation (cf. Parker et al., 2017). The paradigm centers on the idea that firms must open their boundaries to access unique ideas and innovation potential (Chesbrough, 2003). OI offers a process-based lens that goes beyond existing outcome-focused perspectives like generativity (Zittrain, 2006) or network effects (Karhu et al., 2024). It explains how platform owners can deliberately structure openness to facilitate, encourage and manage the flow of external innovation. This makes it particularly suited to theorize how design choices signal innovation opportunities to potential complementors. So far, however, OI has not yet been translated into precise hypotheses about how platform design features affect complementor participation. Furthermore, while prior research in platform governance has explored rules, controls, and incentives for participation, it has not systematically theorized these mechanisms as expressions of OI. In this paper, we build on OI to theorize how specific platform features facilitate and encourage third parties to contribute.

Following OI, we argue that prospective complementors will look for signs that the platform can facilitate knowledge exchange, innovation integration and commercialization of complementary innovation (West & Bogers, 2014). These are captured by three core platform characteristics: First, we examine category variety, referring to the range of categories or genres represented in the platform's content portfolio (Broekhuizen et al., 2021). A broad variety of offerings signals the platform's capacity to support diverse innovation and accommodate varied complementor types (cf. Wareham et al., 2014). Second, we consider boundary resources, such as APIs and development kits, which lower barriers for external developers by enabling access to the platform's core technologies and the knowledge codified into these interfaces (Eaton et al., 2015; Ghazawneh & Henfridsson, 2013). Third, we assess exclusive content offerings as a signal of platform distinctiveness and as a potential mechanism to amplify indirect network effects by attracting more users (Cennamo & Santaló, 2013; Lueker et al., 2022).

These three core platform characteristics align with the logic of OI but also involve non-trivial tensions. For instance, while boundary resources facilitate access to knowledge on how to build on a platform for innovation, they also constrain the autonomy of how complementors build their innovations (Ghazawneh & Henfridsson, 2013; Staub et al., 2022). Similarly, exclusive content can enhance the platform's attractiveness to users but may also raise concerns among complementors about lock-in or limited multi-homing opportunities (Polidoro Jr. & Yang, 2024; Tian et al., 2022). These tensions reflect the paradoxes in OI literature: while greater openness facilitates

external innovation, it can also introduce coordination and control challenges that may deter complementors. These ambivalences show the need for empirical work that clarifies how such features affect complementor participation.

This paper aims to evaluate the impact of the three selected platform characteristics on complementor participation by addressing the following question: *How do core platform characteristics affect complementary participation, theorized from an OI perspective?* We do so by hypothesizing how category variety, boundary resources, and exclusive content signal successful OI performance to complementors. Particularly, we hypothesize that the three platform characteristics positively affect the participation of future complementors. Our empirical study of platform competition in the video game console industry between 2005–2015 provides partial support for our proposition, showing that content variety has no effect on future complementor participation, while boundary resources and exclusive content do.

This study contributes to the platform literature by advancing the theoretical understanding of how platform design characteristics influence complementor participation. While prior work has identified the importance of complementors in creating network effects (Clements & Ohashi, 2005), our study builds on an OI perspective (Chesbrough, 2003; West & Bogers, 2014) to articulate how platform features relating to openness can facilitate and encourage external innovation. By differentiating between the roles of category variety, boundary resources (Ghazawneh & Henfridsson, 2013), and exclusive content (Corts & Lederman, 2009; Landsman & Stremersch, 2011), we offer a more precise account of how platform providers can strategically shape their innovation ecosystems. In doing so, we extend the OI literature beyond the firm-level and contribute to ongoing debates about platform governance (Staub et al., 2022), innovation outcomes (Miremadi et al., 2023), and strategic openness (Cenamor & Frishammar, 2021) in multisided markets.

The paper is structured as follows. We first define platforms and discuss peculiarities of contexts where platforms are the technological architecture for complementary innovation. We then use OI to frame the relationship between platform design features and complementary innovation, followed by the development of hypotheses on how category variety, boundary resources, and exclusive content affect complementor participation. The methodology section introduces the context of the study, which is video game consoles, the data and methods, followed by the results. The next section discusses the findings and contributions and concludes with directions for future research, and the final section concludes with a summary of the paper.

## Theoretical background

### Complementor participation

In many industries, innovation platforms (Hein et al., 2020) have emerged as enablers of complementary innovation as a way to reduce complexity by sharing modules, components, and other assets (Halman et al., 2003; Nambisan et al., 2019; Scholten & Scholten, 2012) and by moving the locus of value creation outside of the focal firm's boundaries (Parker et al., 2017). Focused on system-level outputs (Kretschmer et al., 2022), platforms offer the technological interorganizational architecture (Jacobides et al., 2024) for third-party complementary innovations. This may give rise to the emergence of a platform-based ecosystem, a set of heterogeneous participants, often transcending industries (Autio, 2022), who collectively bring about an ecosystem value proposition (Thomas & Autio, 2020). Within platform ecosystems, specific interdependencies known as non-generic complementarities typically arise among participants (Jacobides et al., 2018). Although participants may multihome across platforms (Rochet & Tirole, 2003), participants must make platform-specific investments that are hard to repurpose (Jacobides et al., 2018). As a result, third parties may not necessarily offer complementary innovations on all competing platforms and hence, platform owners must make an effort to attract them.

Attracting external complementors can help platform firms decrease the cost of developing future products by reducing the extent of redesign necessary for future product generations (Martin & Ishii, 2002). Complementor contributions are the main driver of innovation in mature platform ecosystems (Nerbel & Kreutzer, 2023), a key characteristic of innovation platforms (Hein et al., 2020). Giving complementors access to the platform increases their adoption rates, leading to more diverse and innovative complement offerings (Ondrus et al., 2015). At the same time, harnessing the contributions of complementors in loosely coupled systems (Chang & Sokol, 2022) requires careful governance (Staub et al., 2022) of complementors in terms of desired types and qualities of contributions to ensure the viability and superiority of the ecosystem (Tiwana, 2013).

To harness the contributions of external developers, the OI lens highlights that design capabilities must be shifted outwards and actors have to be granted access to the system (von Hippel & Katz, 2002). Openness can be organizational or technological (Nikayin et al., 2013). Organizational openness is controlled via rules and contracts that determine whether and to what extent complementors can participate in the platform, or it can be embodied in technological design, such as in the form of technological openness (e.g., accessibility of interfaces). For instance, the category

variety featured by the platform captures the variety of content categories such as genres of video games a platform represents via complements. Variety refers to the number of categories, as opposed to depth, which is the number of items per category (Broekhuizen et al., 2021). Category variety can hence be seen as an aspect of access openness (Benlian et al., 2015).

External contributions can be managed by selectively opening up the platform. Technological boundary resources (henceforth boundary resources) such as application programming interfaces (APIs) or software development kits (SDKs) provide such interfaces (Bianco et al., 2014; Ghazawneh & Henfridsson, 2013) and determine the selective opening of a platform's technology towards complementors<sup>1</sup> (Karhu et al., 2018).

OI highlights that the capacity to combine and leverage external contributions is key to motivate participants to participate (von Hippel, 2006). Future complementors will look for indications of successful past integration as an incentive (Kretschmer et al., 2022) to participate (Boudreau & Jeppesen, 2015). Rather than engaging in custom agreements and relations with complementors, platform owners typically maintain arm's length relations with complementors. Signaling (Connelly et al., 2024)—a situation where a signaler, the platform owner, “sends observable signals that carry credible information about unobservable qualities” (p. 1)—is one way to address the problem. Here, the platform owner can signal the platform's quality to attract the participation of future complementors (Hukal et al., 2020). For instance, exclusive content can be seen as a signal of platform quality as it sets the platform apart from competitors (Helfat & Peteraf, 2003), signaling to future complementors that the platform will attract superior indirect network effects (Cennamo & Santaló, 2013; Lueker et al., 2022).

### Open Innovation and platform ecosystems

We use Open Innovation as a lens to frame the relationships between platform characteristics and third-party innovations in platform ecosystems. In its original form, OI entails opening up the boundaries of the firm to external knowledge and

<sup>1</sup> We focus on technical boundary resources (e.g., APIs), considering that these are the most observable and codified forms of boundary resources, making the platform actionable for third parties. From an OI perspective, technical boundary resources are the first-order enablers of knowledge exchange: they make codified knowledge on the platform externally available for innovation purposes. While social boundary resources (see Bianco et al., 2014) are thus out of scope, we note that such forms could play a role in helping complementors understand the platform architecture and development practices, and shaping how technical boundary resources can be utilized by complementors. Ultimately, social boundary resources can complement technical boundary resources.

contributions (Chesbrough, 2003). Through OI, firms obtain, integrate and commercialize external sources of innovation (West & Bogers, 2014). Such flows of knowledge and innovation beyond the boundaries of the firm are not assumed to be completely free, but rather “purposively managed” (Chesbrough & Bogers, 2014, p. 3). Besides various external drivers, OI is affected by a variety of governance and policies controlled by the focal firm (Bogers et al., 2017; Ogink et al., 2023).

While OI originates from the organizational level of analysis, the paradigm is now commonly used on multiple levels, including the platform ecosystem (Bogers et al., 2017). For instance, in his later work, Chesbrough (2011) discussed (service) platforms as a way to realize OI. Importantly, our focus is on platforms as a source and destination of knowledge flows (e.g., an innovation platform, see Hein et al., 2020), and not as a facilitator of knowledge exchange (e.g., a crowdsourcing platform). Applications of OI on platforms and ecosystems can be found in the information systems literature (e.g., Parker et al., 2017) and beyond (e.g., Miremadi et al., 2023).

Regarding our focus on understanding platform ecosystem strategies, scholars have previously argued to use OI as a lens (Altman & Tushman, 2017). Conceptually, such applications of OI as a lens are not trivial. For instance, even seminal studies (e.g., Parker et al., 2017) treat OI and openness as seemingly synonyms. Without defining and interrelating these terms, reductionist views loom that simply label any platform with open APIs as OI (Nambisan et al., 2018, p. 357). In our conceptualization, we rather use OI to explain how openness facets facilitate and encourage complementors to contribute to the platform.

The key OI idea that a focal firm shares knowledge to integrate and commercialize innovation from external parties (West & Bogers, 2014) can be translated into a context of platform ecosystems. In platform ecosystems, the platform owner shares knowledge with complementors on how to build on the platform, for instance through SDKs. The complementary innovations can be integrated into the platform through APIs and commercialized through app stores. The resources to facilitate knowledge exchange, innovation integration, and commercialization are referred to as

boundary resources (Ghazawneh & Henfridsson, 2013). The OI idea that a focal firm controls the level through which resources are made available (Ogink et al., 2023) can also be related to platform ecosystems. In platform ecosystems, platform owners set governance policies (Tiwana et al., 2010), which shape the degree to which boundary resources are available to complementors (Boudreau, 2010; Karhu et al., 2018). Finally, the notion in OI literature that innovations can span widely translates to platform ecosystems as well. The ability to facilitate a broad range of complementary innovations is typically referred to as generativity (Miremadi et al., 2023): the platform's capacity to produce unprompted change driven by heterogeneous actors (Wareham et al., 2014; Zittrain, 2006). OI offers a theoretical lens to explain why platforms provide boundary resources and how they stimulate complementor innovation, whereas generativity captures the observable outcome of these processes. In sum, we conceptualize that the provision of boundary resources facilitates OI by complementors, which produces generative innovation (see Table 1).

Motivations in OI literature vary widely, from extrinsic motives such as financial gains and access to markets (Chesbrough, 2003) and commercialize innovation ideas (Van De Vrande et al., 2009) towards intrinsic motives such as the interest to contribute to solving interesting problems (von Hippel, 2006). The ability to combine and leverage the contributions of other innovators is a key condition for externals to participate in OI (von Hippel, 2006).

Translating this to platform ecosystems, complementors will look for signs that a platform is able to facilitate the creation, integration and commercialization of their inventions. The already existing content variety on the platform provides a sign of its track record of facilitating OI in the past, which reduces uncertainty for potential complementors and signals the platform's openness to diverse contributions (cf. Boudreau, 2012; Cennamo & Santaló, 2013). The provision of boundary resources shows the current technical ability of the platform to enable complementors to integrate and scale their innovations, consistent with prior work emphasizing the importance of modular architectures for third-party innovation (Eaton et al., 2015; Ghazawneh & Henfridsson, 2013). Finally, as actual commercialization

**Table 1** Open innovation in platform ecosystems

Category	Open Innovation (OI) idea	Translation to platform ecosystems
External innovation	Firms obtain, integrate, and commercialize external innovation (West & Bogers, 2014)	Platform owners integrate third-party innovations via APIs and commercialize them via app stores
Knowledge flow	Knowledge flows are purposively managed (Chesbrough & Bogers, 2014, p. 3)	Platform owners strategically manage openness and access through governance policies and boundary resources
Innovation outcomes	OI enables broad innovation outcomes (West & Bogers, 2014)	Platforms support widely varying innovation from diverse actors (Miremadi et al., 2023; Wareham et al., 2014; Zittrain, 2006)

requires future commitment from platform owners as well as users that come specifically to that platform, the exclusivity of content should further motivate complementors to join (Bogers et al., 2017; Ogink et al., 2023; Parker et al., 2017). We focus on these three factors because they jointly capture the primary conditions identified by prior OI and platform literature as enabling complementor participation: (1) proof of past openness (category variety), (2) current ability to support innovation (boundary resources), and (3) future commercialization potential (exclusive content). The next section develops these hypotheses in full, grounding them in the extant literature on OI and platform ecosystems.

## Hypothesis development

For developing the core hypotheses of our study, we translate the OI logic to platform ecosystems, underpinned by related work on platforms and complementors.

Following the logic of OI, external innovators are attracted to thriving ecosystems with a wide range of innovations (von Hippel, 2006). Further, complementors will look for signs that OI has resulted in facilitating knowledge exchange, integration and commercialization of a wide variety of complements in the past (cf. West & Bogers, 2014). As evidence of such “past performance” in successfully facilitating OI, we focus on category variety, which relates to the scope of user demands the platform can cater to via complements.

The ability of OI to facilitate developing and integrating a broad range of innovations is especially important in platform ecosystems as complementors will look to satisfy diverse and volatile consumer demands. Consumer demands on platforms such as video game consoles are often heterogeneous, and platforms can address these demands by expanding to different complement categories. Variety-seeking teenagers, for instance, often use specific video games extensively for several weeks and trade them for a new game without ever returning to it (Gallagher & West, 2009). The ability to facilitate a wide range of complements thus signals

to complementors that the platform helps them to create the diversity of OI outcomes needed to sustain in the market, targeting specific customer niches and preferences. As a side-effect, competition decreases, compared to a platform focused on a narrower set of markets and avoiding crowding situations (Boudreau, 2012; Cennamo & Santaló, 2013).

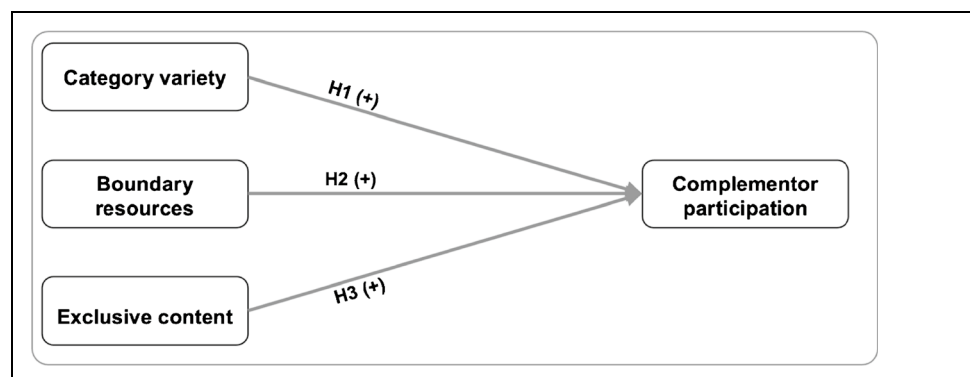
Further, category variety shows that the platform facilitates the commercialization of external contributions. Complementors typically develop along layers of broader categories and target demographics and differentiate at the level of detailed genres (Inoue & Tsujimoto, 2018). Complementors intending to enter a category might be more inclined to do so on a console that already offers complements in a specific game title category. Otherwise, the complementor would need to pioneer the category on that platform, likely involving extra marketing costs. Hence, category variety increases commercialization options for complementors without having to pioneer the game category on that platform. Empirical evidence indeed shows that complement offerings in more different categories attract a more extensive variety of complementors compared to a platform with representation in fewer categories (Boudreau, 2012).

In sum, category variety showcases the past performance of the platform to facilitate OI in terms of knowledge exchange, innovation integration and commercialization. The ability to diversify is especially important in platform markets with volatile and diverse consumer demands. Therefore, we hypothesize (see Fig. 1):

**Hypothesis (H1):** *Greater category variety positively affects complementor participation on a platform.*

OI comprises knowledge exchange, innovation integration and commercialization (Chesbrough & Bogers, 2014). Innovation on a platform requires that complementors have access to codified knowledge about how to build on the platform. Boundary resources constitute the main vehicles for externalizing this knowledge. By providing standardized tools and documentation, they offer actionable resources for third-party developers. In platform ecosystems, the means

Fig. 1 Hypotheses



to facilitate these processes are generally discussed under the concept of boundary resources (Gawer, 2020). We thus focus on the provision of boundary resources, as evidence to complementors that the platform currently has the capacity to facilitate OI activities.

Platform literature stipulates the role of boundary resources for the core processes of OI: knowledge exchange, innovation integration and commercialization. Specifically, boundary resources effectively disclose codified technical knowledge to complementors on how to build on the platform (Baldwin & Woodard, 2009). They allow complementors to design applications which are able to interact with the platform and build on its software and data (Gawer, 2020). Boundary resources further facilitate value co-creation between ecosystem participants (Autio, 2022; Engert et al., 2022). In the context of video games, for instance, boundary resources in the form of suitable tools and resources allow game developers to develop high-quality games that take advantage of the console's unique architecture, enabling a rich experience for end users.

Boundary resources are generally assumed to enable generative innovation in a platform ecosystem (Ghazawneh & Henfridsson, 2013; Karhu et al., 2018; Parker et al., 2016). Studies show that boundary resources help attract future complementors (Eaton et al., 2015; Schrieck et al., 2016). For instance, on Apple's iOS platform, Ghazawneh and Henfridsson (2013) found that the number of applications on the platform increased with every new boundary resource introduced. Previous research suggests that boundary resource provision lowers barriers to entry for new complementors (Hein et al., 2020) and create new ways for complementors to interact with the platform (Kapoor & Agarwal, 2017). At the same time, making boundary resources available could come at the cost of losing control over the platform making their design of strategic value to the platform owner (Wulfert, 2023).

In sum, boundary resources play a crucial role in facilitating OI processes of knowledge exchange, innovation integration and commercialization. Prior studies suggest that making boundary resources available attracts new complementors and allows them to interact with the platform in new ways. Therefore, we posit that:

*Hypothesis (H2): Greater provision of boundary resources positively affects complementor participation on a platform.*

To motivate external actors to engage in OI, the focal firm must show its future commercialization potential of new offerings. In the context of platform ecosystems, the addressable market is typically another user group that is active on the platform (e.g., consumers). We propose that offering exclusive complements on a platform signal to complementors the platform's ability to commercialize

offerings and create indirect network externalities, also in the future.

Exclusive content refers to complements only available on the focal platform and forgoes the availability of these complements on other platforms and improves the competitiveness of the focal platform (Corts & Lederman, 2009; Hagiu, 2009; Yoffie & Kwak, 2006). Content can be offered exclusively through internal development by the platform owner, based on integrating complementors, based on a complementor's decision to remain on a single platform, or exclusive agreements between the platform owner and complementors (Corts & Lederman, 2009; Landsman & Stremersch, 2011). In the latter case, exclusivity usually comes in exchange for a lump-sum payment or an attractive licensing fee. We define exclusiveness as complements that are never available on more than one platform. As Tian et al. (2022) argue, this does not imply exclusivity for a future complementor in a particular domain. Nor does it preclude multihoming at the complementor-level as complementors can also develop exclusive content for several platforms as part of an overall multihoming strategy. In this study, we focus on the effect of a platform's current portfolio of exclusive content on future complementor participation.

Exclusive content differentiates a platform and increases its commercialization potential compared to rivals (Carrillo & Tan, 2021; Cennamo & Santaló, 2013; Hagiu & Lee, 2011; Hermalin & Katz, 2013). Exclusive content makes a platform more attractive to users (Cennamo & Santaló, 2013; Rietveld & Eggers, 2018), which drives indirect network effects (Cennamo & Santaló, 2009) and induces multihoming in users (Ishihara & Oki, 2021). This can even incentivize users to join a lagging platform rather than a leading one (Lee, 2013). Especially in the gaming industry, top-ranking exclusive games often sell consoles (Binken & Stremersch, 2009). For instance, Microsoft's senior vice president overseeing Xbox summarized their strategy and competitive advantage at a press conference, highlighting the importance of top-selling exclusive content: "[Welcome] to Xbox 360, home of the biggest blockbusters and home to fun and entertainment for everyone. [...] Big franchises are a mainstay of our industry. And the biggest sellers are on Xbox 360" (Nicholas, 2008, as cited by Nielborg, 2014, p. 47). Conversely, when a complement is available on multiple platforms, the indirect network effects it generates may weaken (Gil & Warzynski, 2010) as it reduces platform differentiation (Coughlan, 2004; Lee, 2013). Hence, exclusive content can be seen as a signal of platform attractiveness.

More generally, a competitive selection of complements is vital to the platform's sustained future potential (Boudreau, 2012; Parker et al., 2017). Exclusive content is often of higher quality than non-exclusive content (Cennamo

et al., 2018). This is because fully leveraging the technological capabilities of a platform is challenging and complex. In the context of video game consoles, for instance, exhausting technological capabilities would mean optimally allocating tasks across specialized and interdependent processors (Horowitz, 2013). Developers find this highly challenging and are more likely to achieve it when developing for one platform exclusively.

While exclusive complements can drive platform sales, their trajectory is often unpredictable and tends to follow a “hit-and-miss” pattern (Binken & Stremersch, 2009). Rather than judging individual exclusive complements, complementors are therefore likely to evaluate exclusive content at the portfolio-level as quality signals of commercialization opportunities relative to other platforms. Therefore, securing a larger share of exclusive content available across platforms enables a platform to sharpen its competitive edge.

However, these expected effects may taper off as the share of exclusive content increases. Complementors may see a complement portfolio with much exclusive content as a sign of fierce competition they would face upon entry (Lueker et al., 2022). Further, Tian et al. (2022) show that complementors value the ability to easily port complements to different platforms, as this not only expands reach but also provides learning benefits (Polidoro Jr. & Yang, 2024). However, a higher share of exclusive content may also indicate that complementors face greater platform-specific investments and higher porting costs. As porting costs rise, the net benefits of porting and multihoming decrease, potentially to an extent that makes porting unattractive. As a result, the share of exclusive complements may rise. In this sense, higher shares of exclusive might signal difficulties in porting complements to different platforms, which could discourage potential complementors. On balance, however, we expect the positive interpretation to dominate.

In sum, exclusive content poses an important signal to complementors that the platform creates commercialization opportunities for OI outcomes. Platforms with exclusive content stand out from competitors, attract end-users and generate indirect network externalities, which are all essential to commercialize complementary innovations. Therefore, we hypothesize that:

*Hypothesis (H3): More exclusive content positively affects complementor participation on a platform.*

## Methodology

### Study context and data

The video game industry is dynamic and, hence, ideal for understanding complement-platform dynamics. Several

studies (e.g., Cennamo & Santaló, 2009; Rietveld et al., 2019) have used this setting based on its prototypical resemblance to platform ecosystems. Indirect network effects, short product cycles, and intense competition between and within generations characterize the video console industry (Clements & Ohashi, 2005). Gaming is not restricted to consoles, and games such as FIFA are available for video game consoles (e.g., PlayStation 3 and 4), handheld devices (PlayStation Vita), and mobile phones. Nevertheless, we focus on competition between video game consoles because these offer similarly immersive gameplay and more immersive play than touch-based gaming on handheld or mobile devices (Wiegand et al., 2022).

Our sample spans two generations of active video game consoles (seventh and eighth generation, 2005–2015)—a particularly relevant setting for several reasons. Also known as the high-definition (HD) cycle, the seventh generation is characterized by a networked nature of hardware and a significant expansion of storage and computing power (Nieborg, 2014), facilitating high-resolution image and photo-realistic video. These developments were accompanied by a wider transition in the cultural industries (Lessig, 2008) from selling physical, packaged goods towards an on-demand model relying on digital distribution (Broekhuizen et al., 2013). Digital distribution channels lowered barriers to entry, leading to an increase in the number of complementors and increased price competition, rendering the seventh generation onwards particularly suitable for studying how category variety affects the attraction of future complementors. At the same time, SDKs started to proliferate in the industry, ensuring meaningful variation in the provision of boundary resources (Miric et al., 2023). The seventh and eighth generation also stood out with true exclusive complements, making these a mainspring of platform competition (Rietveld et al., 2019), a characteristic that has been on decline as of the ninth generation (Royte, 2024). Together, these characteristics render the seventh and eighth generation of video game consoles suitable to study the implications of category variety, boundary resources, and exclusive content for complementor participation.

We created a panel from multiple sources. We relied on quarterly global sales data from the analytic website VGChartz for most of our data set. This industry research firm has compiled a game database covering over 40,000 titles and 1.5 million data points, spanning two generations of consoles and game titles. It also documents every game title’s release date, publisher, developer, genre, and the platforms on which it was released. We validated the data by cross-checking with Mobygames.com, which has been consulted for information on game titles by other studies (Corts & Lederman, 2009). Information on developers allowed us to identify when new complementors joined a platform as captured by our dependent variable. For category variety,

**Table 2** Overview of measures

Variable		Definition
Dependent variables	Complementors	The number of unique game developers that enter the ecosystem of platform $i$ in quarter $t$
	Games	The number of new game releases on platform $i$ in quarter $t$
Independent variables	Category variety	The proportion of game genres platform $i$ is represented in in quarter $t - 1$ over the total existing game genres in quarter $t - 1$
	Boundary resources	The number of game engines available for platform $i$ in quarter $t - 1$
	Exclusive content	The proportion of exclusive game titles produced on platform $i$ in quarter $t - 1$ over total exclusive game titles for all platforms in quarter $t - 1$
Controls	Installed base	Unit sales of platform $i$ in quarter $t - 1$
	Generation	Dummy variable for the period in which both a newer and an older generation of a platform coexist
	Seasonality	Dummy for the last quarter of the year

relying on data by an industry research firm has the advantage that categories in terms of genres are defined by analytic websites rather than the platforms, publishers, or developers and hence allow for comparison across platforms. Games in the same genre are characterized by similar game play rather than similar setting, story line, or medium of play (Adams, 2014). Here, genres serve as a proxy for markets, and the availability of a game title on a platform in a specific genre is seen as catering to this market. To construct our measure for boundary resources, we relied on information on game engines available for each console (including release dates), published by the Internet Game Database (IGDB), and validated by cross-checking with online news and press releases. Game engines serve as the key technical interface through which complementors (game developers) access and build upon the console's technological architecture. They provide standardized tools, libraries, and development workflows that lower barriers to entry and enable innovation at scale. This conceptualization differs from other platform settings (e.g., mobile, e-commerce) where boundary resources are typically framed in terms of APIs, SDKs, or developer portals. In the console industry, supported game engines play a particularly central role because they shape which development tools are available, how easily developers can port content across consoles, and the extent to which the platform can attract a broad set of complementors (Jungherr & Schlarb, 2022). Finally, we again relied on game release data from VGChartz to identify games that were never released on more than one platform for our measure of exclusive content.

In summary, the dataset covers video game consoles of two generations (seventh and eighth generation): Nintendo's Wii and the WiiU, Sony's PlayStation 3 and PlayStation 4, and Microsoft's Xbox360 and Xbox One across

two generations. The data and code used in this study are included in an online appendix.<sup>2</sup> The package includes instructions for reproducing all figures and analyses on which the results are based.

## Measures

An overview of all measures is presented in Table 2. We define the dependent variable *complementor participation* in two ways. *Complementors* is defined as the number of unique game developers that enter the ecosystem of platform  $i$  in quarter  $t$ . We refer to unique game developers to imply that a game developer with more than one game for a platform is counted only once, irrespective of the number of games by that game developer on the specific platform. As an absolute count, this variable directly measures the ecosystem's growth and the platform's reach. *Games* counts the number of new game releases on platform  $i$  in quarter  $t$ , and is a measure of complementor innovation. We exclude first-party complementors and games from both variables as they may confound the results. Together, these definitions capture complementor participation in terms of its extensive and intensive margin (respectively).

Regarding independent variables, we measure the *category variety* as the proportion of game genres platform  $i$  is represented in in quarter  $t - 1$  over the total existing game genres in quarter  $t - 1$ . A specific genre represents a user group that is characterized by distinct demands. Genres are defined by analytic websites such as VGChartz and are a category of games characterized by similar game play rather than similar setting, story line, or medium of play (Adams, 2014). Here, genres serve as a proxy for markets, and the availability of a game title on platform  $i$  in a specific genre is seen as catering to this market. An overview table of genres in the data is available in the online appendix.

We operationalize *boundary resources* as the number of game engines available for platform  $i$  in quarter  $t - 1$ .

<sup>2</sup> Available at: <https://doi.org/10.17605/OSF.IO/8KFYM>

Game engines are software tools to equip game developers with features to support core game development areas such as audio, video, physics, or animation. Every video game needs a game engine, either internally developed, externally sourced, or externally sourced and modified. Hence, game engines are at the very core of video game development and are a suitable proxy for boundary resources. We measure *exclusive content* as the proportion of exclusive game titles produced on platform  $i$  in quarter  $t - 1$  to total exclusive game titles for all platforms in quarter  $t - 1$ . An exclusive game title is available only on the focal platform and never on a rival platform during the observation period. Hence, exclusive content is the platform's ability to negotiate exclusive contracts with game developers, as also used by Cenamo and Santaló (2009).

We define exclusive content and category variety as proportions because we expect complementors to weigh exclusive content on a particular platform compared to other platforms. Similarly, we expect them to compare portfolios of served game genres across platforms rather than the absolute number. With boundary resources, it is more likely that complementors look for specific game engines rather than taking a portfolio perspective. Hence, we rely on the absolute count of boundary resources rather than their proportion.

We control for a platform's *installed base* in terms of unit sales of platform  $i$  in quarter  $t - 1$ , as it influences indirect network effects and the intention of complementors to develop games for a platform. Although one may intuitively use a cumulative measure for installed base, prior research has shown that cumulative measures may overstate network effects (Nair et al., 2004; Rietveld & Eggers, 2018). The logic is that users are primarily active in the time right after the purchase and may become inactive later. The video game industry shows a strong seasonal pattern as many new games and consoles are released in the last quarter of the year. Therefore, we use a dummy (*seasonality*) to control for the last quarter of the year.

Whenever a new generation of a platform is released, users are drawn to the new and technologically superior platform. This decreases complementors' support for the older version of that platform, as the direct network effects tend to decrease with the introduction of newer generations. As in Srinivasan and Venkatraman (2010), we use a dummy variable (*generation*) for the period in which both a newer and an older generation of a platform coexist.

## Estimation method

As discussed above, we seek to estimate whether category variety and boundary resources, as well as exclusive content, are related to the number of complementors offering complements for a specific platform. We opt for a count model as both dependent variable specifications (complementors and

games) are non-negative integers. We chose the fixed-effects specification as is suitable for addressing panel data caused by several years of observations.

The most common count model, the Poisson model, requires that the variance and the mean are equal (Sun & Zhao, 2013), which does not hold based on our dependent variables (their variances strongly exceed their means). In this case, a negative binomial (NB) distribution may be a better fit. We evaluate the goodness-of-fit of different models based on the Akaike information criterion (AIC) and the Bayesian information criterion (BIC) (Washington et al., 2020). The model with lower AIC and BIC is usually preferred over other models. Both suggest that the negative binomial model fits best, comparing the Poisson model with fixed-effects, the NB model, and the NB model with fixed-effects and suppressed constant. We estimate the model using the maximum likelihood estimator (MLE) (Washington et al., 2020).

Theoretically, the causation could also be opposite to what we hypothesize (from boundary resources to complementors) as game engines (these underlie the variable boundary resources) could belong to the very game developers who are the complementors. This would mean that boundary resources are driven by the number of complementors. The other independent variables (category variety and exclusive content) could also be driven by the dependent variable. If we were studying a situation with only two platforms, all the variation would be explained by exclusive games since non-exclusive games are available on both platforms. This is less the case in a three-way competition. However, an exclusive game, as we define it, may increase complementor participation, if it is the sole contribution of the respective complementor to the industry. This may not be the case if it is part of a complementor-level multihoming strategy, consisting of several exclusive games (Tian et al., 2022). Similar concerns may apply to category variety. The serving of a genre manifests as the platform having a game on offer in that genre. In the case of high breadth (many categories) and low depth (few games per category), our dependent variable could also affect category variety. We use a lag of each independent variable to capture their effect on future complementors.

Network effects are a central theme in platform research, entailing that the number of users and complementors (via the number of complements) are mutually dependent. In our case, the platform's present users (installed base) attract new complementors. These new complementors likely attract new users via the complements they offer, and so forth. This feedback loop presents a source of endogeneity (Semadeni et al., 2014) that we address with a two-step estimation approach and by including an exogenous variable (*exchange rate*).

We follow past research that addresses endogeneity resulting from installed base via the costs of consoles (Clemons & Ohashi, 2005). We instrument installed base via the cost of a console based on the exchange rate between the country of production and the US\$. Production costs are likely to affect retail prices<sup>3</sup> for several reasons. The profits in the industry are generated from software sales and royalties rather than hardware sales (Lee, 2012). Consoles are often sold at prices that equal production costs or even at a loss to spur income from software sales and royalties. Hence, one can expect the exchange rate with the country of production to affect prices and, ultimately, hardware demand. There should be no reverse effect of video game production on exchange rates, and one can expect that exchange rates influence complementor participation only via console sales, but not directly. We obtained information on exchange rates from fxtop.com and used quarterly averages.

The two-step approach is not readily implemented in Stata with the negative binomial fixed-effects model. Hence, we run the two steps manually, with the disadvantage that the standard errors of the first stage are not corrected. Details regarding first-stage estimations can be found in the Appendix section.

## Results

### Descriptive statistics

Table 3 contains summary statistics. The panel contains 139 observations across six platforms (PS3, Xbox 360, Wii, Wii U, PS4, and Xbox One) with an average of 23.2 time periods per platform (the data is recorded quarterly). The dependent variable has a mean of 10.3 complementors, indicating that, on average, 10.3 complementors join a platform ecosystem in a quarter. The minimum (0) and maximum (63) show sufficient variation in the data.

Multihoming may bias the results since we observe complementor participation via their release of games for a platform. If complementors chose to release games on all studied platforms, their decision may be unrelated to the studied dimensions. The 2199 observed games were released

<sup>3</sup> The data is not limited to the United States. Nevertheless, the exchange rate between the country of production and the US\$ likely indicates the exchange rates with major markets for video game consoles. Further, the exchange rates only vary between platforms to the extent that the platforms are produced in different countries. Most of the video game consoles in the seventh and eighth generations were produced by Foxconn. In cases where we could find the manufacture but not the specific production location, we assumed that the platform was produced in the country in which the biggest production site of the manufacturer is located.

**Table 3** Descriptive statistics

Variable		Mean	Std. dev	Min	Max
Complementors	Overall	10.273	9.340	0.000	63.000
	Between		3.335	3.417	12.625
	Within		9.038	-2.060	60.940
Games	Overall	22.094	19.420	0	110
	Between		7.382	5.917	26.222
	Within		18.627	-4.129	105.871
Category variety	Overall	0.646	0.250	0	1
	Between		0.108	0.464	0.747
	Within		0.228	0.103	1.103
Boundary resources	Overall	19.050	7.901	7	30
	Between		7.702	8.333	25.375
	Within		3.673	5.255	24.255
Exclusive content	Overall	0.281	0.237	0	1
	Between		0.098	0.102	0.407
	Within		0.222	-0.126	1.048
Installed base	Overall	14.221	1.045	10.840	16.271
	Between		0.489	13.457	14.970
	Within		0.998	10.946	16.378
Generation	Overall	0.223	0.418	0	1
	Between		0.160	0	0.361
	Within		0.399	-0.138	0.992
Seasonality	Overall	0.252	0.436	0	1
	Between		0.003	0.250	0.256
	Within		0.436	-0.005	1.002
Exchange rate	Overall	0.122	0.054	0.029	0.164
	Between		0.051	0.032	0.161
	Within		0.008	0.0971	0.136

*Note.* The data contain 139 observations across six platforms, averaging 23.2 observations per platform. Next to the global mean ( $\bar{x}$ ), the summary statistic decomposes the variable  $x_{it}$  into between ( $\bar{x}_i$ ) and within ( $x_{it} - \bar{x}_i + \bar{x}$ ), adding the global mean back in to make the results comparable (StataCorp, 2017). The statistics refer to installed base after logarithmic transformation

3457 times, indicating significant multihoming. Nevertheless, Table 4 shows that roughly 85% of the games were released on less than three platforms, showing that release strategies vary across games. This is irrespective of precise release dates since these statistics account for whether the complementors multihomed and not in which sequence the games were released.

### Main results

We present the results in Table 5 and plot coefficients in Fig. 2, comparing results from the two specifications of the dependent variable. For each variable on the Y-axis, point estimates with 95% confidence intervals are displayed: the estimates from model 1 of Table 5 with complementors as the dependent variable (in blue, plotted above), and model

**Table 4** Multihoming games

Number of platforms a game is released on	Game count	Percent
1	1365	62.07
2	519	23.6
3	235	10.69
4	56	2.55
5	19	0.86
6	5	0.23
Total	2199	100

2 with games as the second specification of the dependent variable (in red, plotted below). Variables whose confidence intervals do not cross zero can be interpreted as statistically significant at the 5% level. We rely on conditional fixed-effects negative binomial regressions to estimate the effect of boundary resources, category variety, and exclusive content on complementor participation (in its two definitions).

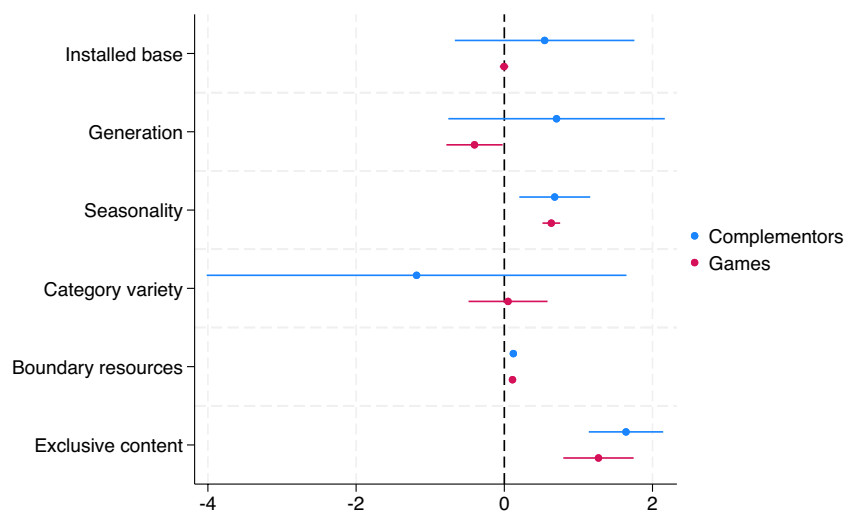
In model 1, complementor is the dependent variable, games in model 2. The models contain platform and year fixed effects as these achieve the best fit compared to specification without (across both definitions of the dependent variable). Hypothesis 1 states that category variety positively

**Table 5** Second-stage regression results

	(1)	(2)
	Dependent variable: complementors	Dependent variable: games
	Negative binomial fixed-effects regression	Negative binomial fixed-effects regression
Installed base	0.544 (0.618)	-0.00267 (0.0292)
Generation	0.705 (0.745)	-0.401** (0.194)
Seasonality	0.680*** (0.244)	0.635*** (0.0608)
<b>Category variety</b>	-1.184 (1.445)	0.0367 (0.272)
<b>Boundary resources</b>	0.122*** (0.0210)	0.111*** (0.0183)
<b>Exclusive content</b>	1.642*** (0.256)	1.273*** (0.242)
Fixed effects	Platform, year	Platform, year
Log-pseudolikelihood	-312.2	-395.8
AIC/BIC	654.4/698.4	821.8/865.8
Obs., platforms	139/6	139/6

Note. Standard errors in parentheses. \*\*\* $p < 0.01$ , \*\* $p < 0.05$ , \* $p < 0.1$

**Fig. 2** Point estimates and confidence intervals of regression estimates



affects complementor participation. However, its coefficients (model 1:  $\beta = -1.184$ ,  $p = 0.413$ ; model 2:  $\beta = 0.0367$ ,  $p = 0.893$ ) are insignificant across most models and do not support the hypothesis. Hypothesis 2 states that greater provision of boundary resources positively affects complementor participation. The results support this hypothesis based on positive and highly significant coefficients across all models (model 1:  $\beta = 0.122$ ,  $p = 0.000$ ; model 2:  $\beta = 0.111$ ,  $p = 0.000$ ). Hypothesis 3 argues that exclusive content positively affects complementor participation—the coefficients for exclusive content are highly significant and positive across all models (model 1:  $\beta = 1.642$ ,  $p = 0.000$ ; model 2:  $\beta = 1.273$ ,  $p = 0.000$ ), supporting our argument.

The control for the installed base is statistically insignificant for new complementor entry and likewise insignificant for new game releases (model 1:  $\beta = 0.544$ ,  $p = 0.379$ ; model 2:  $\beta = 0.00267$ ,  $p = 0.909$ ). This is expected as complementors typically join early and continue to release games once they have committed to one or more platform ecosystems based on platform-specific investments (Jacobides et al., 2018). The control for the presence of a new generation behaves as expected (model 1:  $\beta = 0.705$ ,  $p = 0.344$ ; model 2:  $\beta = -0.401$ ,  $p = 0.038$ ). Since most new complementors join a platform early in its lifespan, the presence of a new generation has little impact as time fixed effects also capture these dynamics. In contrast, as complementors continue to release games on platforms, introducing a new console may lead to a sharper contribution change, as indicated by the significant and negative coefficient. Finally, seasonality has a positive and significant coefficient, with a higher coefficient in the models estimating new game releases (model 1:  $\beta = 0.680$ ,  $p = 0.005$ ; model 2:  $\beta = 0.635$ ,  $p = 0.000$ ). According to our expectations, it indicates that more complementors join a console, and more games are released in the Christmas season, characterized by strong sales.

Since, as we have argued, higher shares of exclusive content may also be interpreted as signals of fierce competition (Lueker et al., 2022) or difficulties to port complements to other platforms (Tian et al., 2022), we tested whether the effect showed any signs of leveling or declining. Table 6 in Appendix contains estimations with squared terms of exclusive content. The analysis provides no robust evidence of a non-linear (U-shaped or inverted U-shaped) relationship: the squared term of exclusive content is statistically insignificant across both model specifications (model 1:  $\beta = 0.147$ ,  $p = 0.901$ ; model 2:  $\beta = 0.377$ ,  $p = 0.650$ ).

Further, we considered genre-level competitive dynamics of exclusive content to get a firmer grip on the underlying mechanism. Following Lueker et al.'s (2022) argument, exclusive content may also be a sign of strong competition complementors may face after entry. Since much of competition takes place at the genre-level (Inoue & Tsujimoto, 2018), exclusive content published in genres with high shares of exclusive

content may indeed be seen as a sign of expectable fierce competition, whereas exclusive content published in genres with low shares of exclusive content may be seen as a signal of quality. To that end, we retrospectively identified average levels of exclusive content per genre and platform and considered whether exclusive content on a platform was published in genres with more-than-average exclusive titles (high competition) or less (low competition). We then expressed high and low competition exclusive content as a share of all available exclusive content across platforms in the respective quarter, in line with our original operationalization of the main variable exclusive content. The results are reported in Table 7 in the Appendix. Complementors regressed on both versions of exclusive content shows that both high competition (model 1:  $\beta = 0.959$ ,  $p = 0.030$ ) but even more so low competition exclusive content (model 1:  $\beta = 1.450$ ,  $p = 0.003$ ) affect complementor participation, as indicated by the higher magnitude of the coefficient. With games as the dependent variable, the picture is even more pronounced, with a significant coefficient only observed for low competition exclusive content (model 2:  $\beta = 1.247$ ,  $p = 0.002$ ). Together, these results suggest that the quality-signaling role of exclusive content prevails over its competition-signaling capacity.

We tested several alternative specifications. We alternatively specified exclusive content as a count of exclusive content on a platform at time  $t$  rather than as a share. This alternative specification avoids the additional link between the platforms, as a new exclusive game on the focal platform increases its count and the overall count, and hence also influences the ratio of the other platforms. These additional estimations lead to very similar results (model 1:  $\beta = 0.00566$ ,  $p = 0.013$ ; model 2:  $\beta = 0.00585$ ,  $p = 0.012$ ), qualitatively speaking, and hence support our argument (reported in Table 8 in the Appendix).

Moreover, estimations with quarterly fixed effects lead to very similar conclusions based on comparable coefficients and significances, although with worse fit (not reported). To test for the robustness of our distributional assumptions, we re-estimated the results in Table 5 based on a Poisson distribution (not reported). The results from the Poisson specification remain qualitatively consistent with the baseline negative binomial specification in terms of significances and signs of key variables.

## Discussion

Drawing on the OI perspective, our results clarify which aspects of platform openness most effectively encourage complementor participation. Specifically, we examined how category variety, boundary resources, and exclusive content affect complementor participation, as these characteristics signal that the platform can facilitate knowledge exchange, innovation integration, and commercialization

of complementary innovation (West & Bogers, 2014). We hypothesized that all influence complementor participation positively and tested the relationships in the seventh and eighth generations of video game consoles. Our results show that while category variety does not affect complementor participation, boundary resources and exclusive content have a positive effect.

Regarding category variety, we do not find support for the previous research that emphasizes the importance of a diversified complement portfolio in terms of covered content genres (Boudreau & Jeppesen, 2015; McIntyre et al., 2020). This is surprising as platform owners must manage collective value creation of the ecosystem (Rietveld et al., 2019) which manifests in the form of category variety via the individual contributions of complementors. Since it is important for the adoption decision of users (Gupta et al., 1999; Rietveld & Eggers, 2018), we expected an effect of complementors via indirect network effects. From an OI perspective, the lack of effect suggests that diversity in existing content does not necessarily signal openness to future innovation. Rather, complementors may interpret variety as an outcome of prior openness rather than as an invitation for new innovation.

The findings regarding boundary resources align with Ghazawneh and Henfridsson (2013), who attribute a prominent role to boundary resources in complementor attraction. Our results suggest that the resourcing function of technical boundary resources has a positive effect on complementor participation. This supports previous work that technical boundary resources fulfill a role in externalizing codified knowledge on how to utilize platforms (Bianco et al., 2014; Engert et al., 2022). While boundary resources can also have a role in securing or controlling usage of platforms and thus constraining innovation processes (Ghazawneh & Henfridsson, 2013), we found that the resourcing role prevails in our study context. This finding contributes to ongoing discussion on the dual role of boundary resources. An alternative explanation is that social boundary resources (e.g., values, relationships, participation rules) might play more of a securing or controlling role, and explain why availability of technical boundary resources can lead to higher or lower degrees of innovation.

Further, our findings stress the positive impact of exclusive content in attracting new complementors. In post hoc analyses inspired by potential competition signaling effects of high shares of exclusive content (Lueker et al., 2022), we showed that the quality signaling capacity likely prevails over its competition signaling capacity. This finding resonates with Lee (2013), who shows that an industry without exclusive content may reinforce the incumbent's leading position. In a similar spirit, exclusive content may convey hard-to-measure platform aspects of platform attractiveness such as monetization opportunities to future complementors.

In summary, our findings show that exclusive content increases the attractiveness of a platform to future complementors, compared to a platform with less exclusive content.

Interpreting these findings through an OI lens suggests that complementors respond differently to signals of openness across time. Category variety reflects the platform's historical ability to integrate diverse innovations (past openness), boundary resources represent current support for collaboration (present openness), and exclusive content signals future commercialization opportunities (anticipated openness). Our results indicate that complementors are most responsive to signals of present and future openness.

## Theoretical implications

The paper offers several contributions. First, we build on the literature of open innovation (Chesbrough, 2003) and external innovation (cf. Parker et al., 2017) and translate core ideas of OI into the context of platform ecosystems. Particularly, we argue that complementors will look for signs that OI has resulted in successful knowledge transfer, integration and commercialization, core features of OI (West & Bogers, 2014). We conceptualize category variety, boundary resources, and exclusive content, core features of platform design, as drivers for complementor participation (Broekhuizen et al., 2021) by theorizing how specific platform features facilitate or signal the platform's capacity to support complementor innovation (Arend & Lévesque, 2010). We contribute to the dimensionality of OI in the context of platform ecosystems, something scholars still need to agree on (Broekhuizen et al., 2021), responding to calls for research on the drivers and consequences of changes in platform openness (Gawer, 2014).

Further, it adds to the growing literature on platform governance (Rietveld et al., 2019; Staub et al., 2022; Wareham et al., 2014) and platform-based innovation (Miremadi et al., 2023), particularly on how the platform hub federates and orchestrates an ecosystem of complementors for complementary innovation (Eaton et al., 2015; Rietveld & Schilling, 2021; Rietveld et al., 2019). Our study contributes by testing direct effects of key drivers on complementor participation, rather than the more frequently-studied indirect link via a user-related construct and indirect network effects (e.g., Cennamo & Santaló, 2019). We extend existing research on drivers and inhibitors of complementor participation (Broekhuizen et al., 2021; Engert et al., 2023). Previous research has mainly viewed complementor participation as a decision at the outset of the platform's existence (e.g., Caillaud & Jullien, 2003; Evans & Schmalensee, 2010) or focused on single factors for complementor participation (e.g., Fang et al., 2021; Foerderer, 2020; Heimbürg et al., 2024). As we

theorize complementor participation from an OI perspective, we show how openness features of the platform drive external innovation.

By framing the availability of boundary resources within an OI perspective, we suggest that technical boundary resources act as observable signals of openness for complementors and provide the most readily usable tools for accessing codified knowledge on how to build on the platform. This focus on technical boundary resources deliberately isolates the technological dimension of openness, which is often easier to observe and measure consistently across platforms. In doing so, we enhance the understanding of the resourcing function of boundary resources (cf. Ghazawneh & Henfridsson, 2013) and show that their enabling effect on complementor participation tends to prevail in our context. At the same time, our study leaves out social boundary resources (e.g., governance mechanisms, relationships, community norms) which steer how technical affordances are communicated and used (Bianco et al., 2014). Moreover, we add by conceptualizing exclusive content at the portfolio-level of complements as a distinctive feature of platform ecosystems to signal their potential to *commercialize* OI outcomes towards future complementors. Existing studies considered the effect of entry of third-party exclusive content on competing complementors, learning-benefits from complementor-level multihoming (Polidoro Jr. & Yang, 2024) or the effect of platform compatibility on future multihoming decisions (Tian et al., 2022). We add by studying the effect of exclusive content at the portfolio-level on future complementor participation, moving beyond existing theorizing of exclusive content as a driver of indirect network effects. We show that it drives complementor participation, adding to the small but growing literature on the competitive dynamics surrounding exclusive content (e.g., Lueker et al., 2022; Polidoro Jr. & Yang, 2024; Tian et al., 2022).

### Practical implications

The results can guide platform owners on how to increase complementor participation. In practice, relations with complementors require nourishing and cherishing (McIntyre & Srinivasan, 2017). Our study shows that potential complementors will look for signs of successful OI performance of the platform, something that platform owners can signal via the proposed dimensions of platform design. Thereby, our study helps practitioners create and maintain a diverse ecosystem of complementors. Particularly, the results show that boundary resources are positively linked to complementor participation as their resourcing function likely prevails over the securing function. For platform managers, this suggests adding boundary resources helps attract complementors as their resourcing function dominates. Moreover, we argue

for exclusive content as a driver of complementor participation. The findings show that exclusive content can be used strategically to attract future complementors as it functions as a signal of future OI performance and commercialization opportunities.

### Limitations and future research

Several limitations apply. First, while focusing on complementor dynamics, our data reflect video gaming platforms and their ecosystems. From the model's perspective, a complementor can join one of the covered platforms, several, or none. However, the model does not reflect the many other options beyond video console gaming that complementors face in practice. Although previous research has shown that competition mainly occurs between gaming devices of similar immersion (Wiegand et al., 2022), future research could incorporate these aspects by covering several platform classes (consoles, handheld devices, PCs).

Second, generalizability may be affected as industry-wide trends have shaped the nature of the studied constructs category variety, boundary resources, and exclusive content since the eighth generation of video game consoles. Competition has moved from being driven by hardware identities to being shaped by ecosystem features such as bundles of categories, cross-play, and subscriptions.<sup>4</sup> For instance, category competition has been reshaped based on trends to more independent complementors, and subscriptions that allow users to access curated lists of games (Van Crombrugge & Stremersch, 2025). This means that users engage with multiple genres, and platforms compete on engagement across genres rather than single genres. Relatedly, a rise in third-party boundary resources such as the Unreal or Unity game engines has supported the rise of independent complementors and facilitated cross-platform development (Jungheer & Schlarb, 2022), and cross-play enables cross-platform multiplayer functionality. Dynamics around exclusive content have changed with platform owners prioritizing ecosystem growth, publishing some up to now exclusive blockbuster complements on competing platforms (Royte, 2024).

Similarly, generalizability to other industries may be affected by the nature of the video game context. For instance, in contrast to the video game platforms, mobile operating systems such as Android and iOS, or web browser platforms such as Chrome or Firefox do more or less entirely without exclusive content as multihoming is common among developers (Hyrynsalmi et al., 2016) in these platform ecosystems. The extent to which multihoming plays a role in the specific platform context may be an important contextuality.

<sup>4</sup> <https://www.howtogeek.com/the-next-console-war-will-be-fought-over-subscriptions-and-streaming/>

Third, our focus on technical boundary resources leaves social boundary resources unexplored. Future research could build on our approach by integrating these social dimensions, examining how they interact with technical resources to shape complementor participation. Such work could help clarify when the securing function of boundary resources (Ghazawneh & Henfridsson, 2013) becomes more salient and whether social mechanisms can amplify or dampen the enabling effect of technical affordances.

Fourth, the findings regarding exclusive content may be limited by other factors that affect exclusivity choices. Although exclusive content has been central to video game console competition in the studied period, exclusive content may also have been the result of high porting costs, technical limitations, or strategic considerations by complementors. This would reduce the extent to which exclusive content serves as a quality signal. Future research could attempt to capture these effects.

Future research could further disentangle the effects of exclusive content on complementor participation. We have considered exclusive content at the portfolio-level of complements on a platform as a distinctive characteristic of the platform. Exclusive content could be further distinguished by type, such as in-house, third-party exclusive, or particularly successful and highly-ranked exclusive titles (Castro & Sant'Anna, 2023). Further, in our conceptualization of exclusive content as a quality signal, we have defined exclusive content as content that is never available on other platforms. Next to accounting for infinite exclusivity, future research could disentangle the competitive dynamics entailed in temporally limited exclusivity or service-specific exclusivity,<sup>5</sup> reflecting recent industry trends. For instance, the sequence and temporal spacing of multihoming game release across platforms could convey relevant platform characteristics to complementors such as commercialization advantages or difficulty of development for a specific platform.

Fifth, endogeneity could be further reduced by including additional instruments for the installed base and instrumenting the independent variables. We are not aware of promising instruments for category variety. Previous studies have instrumented exclusive content based on exclusive content in the previous console generation (Cennamo & Santaló, 2013). Data availability prevented using this instrument as this would come with the loss of one generation of video game consoles in the current data set. Previous approaches to instrumenting boundary resources (based on average boundary resource levels, see Zapadka, 2022) are likely

not independent of the current study's frame of boundary resources.

Finally, future research could conceptualize OI based on more targeted measures of complementor participation, such as attracting especially productive, successful, or innovative complementors. Moreover, the theorized spill-over effects driving the relationship between exclusive content and future complementor participation could be incorporated as mediation effects. Lastly, our estimations show which drivers affect complementor participation. Future research could study which drivers affect complementor participation effectively in terms of the costs incurred to address them.

## Conclusion

Attracting the participation of complementors is a central strategic concern for digital platform owners (McIntyre & Srinivasan, 2017). Since theoretical understanding of the drivers of complementor participation is limited, this study drew on Open Innovation (OI) as a lens to frame the relationships between platform characteristics and third-party innovations in platform ecosystems. Translating OI to platform ecosystems, this paper argued that future complementors will look for signals that the platform is able to facilitate the creation, integration, and commercialization of complementor's innovations (West & Bogers, 2014). Motivating category variety, boundary resources, and exclusive content as such signals, this paper aims to evaluate the impact of these three selected platform features on complementor participation by addressing the following question: How do platform characteristics affect complementary participation, theorized from an OI perspective? Addressed in the context of three video game platforms across two generations, this paper shows boundary resources and exclusive content positively affect complementor participation, as opposed to category variety. In doing so, our paper provides a more differentiated account of how open innovation informs strategies for complementor participation, and in turn platform design. Our study hence extends the literature on open innovation beyond the firm level and to the ecosystem level, with implications for platform governance, innovation outcomes, and strategic openness.

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<sup>5</sup> For instance, the Premium version of the PlayStation.Plus subscription plans includes exclusive access to specific games (Sony Interactive Entertainment Europe Limited, 2025).

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**Data Availability** The data that support the findings of this study are openly available at: <https://doi.org/10.17605/OSF.IO/8KFYM>.

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