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Contrasting Open Innovation and Resource-based View

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Abstract

This paper analyses strategies for platform owners to increase complementor participation on the platform. Specifically, it draws on open innovation (OI) and the resource-based view (RBV) to isolate three drivers of complementor participation, namely breadth of content offerings and boundary resources (related to OI), and exclusive content (associated with RBV). We hypothesize that higher levels of each of these drivers increase the platform's attractiveness to future complementors and increase complementor participation. Based on negative binomial fixed effects regressions in the context of video game consoles, we find that boundary resources and exclusive content, but not breadth of content offerings, are positively related to complementor participation. This shows that drivers from both OI and RBV relate to complementor participation. The results have implications for the orchestration of platform ecosystems.

Keywords: Platform, ecosystem, complementor participation, resource-based view, open innovation

Introduction

Digital platforms and platform ecosystems have proliferated by creating scalable systems that link third-party makers of complementary products (complementors, hereafter) to users (Chen et al., 2022; de Reuver et al., 2018). Platform-based ecosystems have received increasing attention for describing competitive environments (Jacobides et al., 2018). When users decide whether to buy into a platform ecosystem, they often consider the number and quality of the available complementary products (complements, hereafter) next to the platform's characteristics (Rietveld & Schilling, 2021). This effect is known as the indirect network effect (Katz & Shapiro, 1985) and highlights the importance of complementors for the platform's overall success (Boudreau, 2010). Attracting complementors, hence, is a central question for platform owners, as their participation and the availability of complements cannot be taken for granted (McIntyre & Srinivasan, 2017). Potential complementors are less abundant than often assumed (McGowan & Hienerth,

2022), stressing the importance of complementor strategies. This has led scholars to study drivers of complementor participation (e.g., Eaton et al., 2015; Petrik & Herzwurm, 2020; Rietveld & Eggers, 2018), revealing two seemingly opposing paradigms: open innovation and resource-based view.

On the one hand, the *open innovation* (OI) paradigm centers on the idea that most unique ideas and innovation potential exist beyond the confines of organizations (Chesbrough, 2003). Since complementors, by definition, lie outside of the focal firm, an open and inclusive platform ecosystem strategy would benefit complementor participation. Following this paradigm, the provision of *boundary resources*, tools and regulations that serve as an interface between platform owners and complementors (Eaton et al., 2015; Ghazawneh & Henfridsson, 2013; Petrik & Herzwurm, 2020), or the platform's *breadth of content offerings* (Broekhuizen et al., 2021) could be seen as drivers for complementor participation. The breadth of content offerings shows the content inclusiveness on a platform and signals this to prospective complementors.

On the other hand, the *resource-based view* (RBV) of the firm suggests that competitive advantage can be achieved by exploiting what is unique, distinctive, or valuable (Barney, 1991). Firms gain a competitive advantage by capitalizing on environmental opportunities, responding to external threats, and utilizing internal strengths that are valuable, rare, inimitable, and organized to capture value (VRIO) (Barney, 1991). Following this logic, the platform owner would be well-advised to craft distinct positions to attract complementors. For instance, attracting *exclusive content*, content only published on the focal platform (Cennamo & Santaló, 2013; Corts & Lederman, 2009; Srinivasan & Venkatraman, 2010), is a way to differentiate the platform and signal prospective platform success to future complementors.

Whereas OI has received some attention regarding complementor attraction (West, 2003), strategic levers to differentiate platforms have less so. In this paper, we compare these paradigms concerning complementor participation. We study *how platform accessibility in terms of innovation and participation costs affect complementor participation*. Particularly, we investigate how boundary resources, breadth of content offerings (following OI logic), and exclusive content (following RBV logic) affect complementor participation[1].

We address this question based on longitudinal data on the seventh and eighth generations of video game consoles. The results show that boundary resources and exclusive content are positively related to complementor participation, as opposed to exclusive content. This means that both OI and RBV are relevant in attracting complementors. This study contributes to the literature on ecosystem orchestration (Gawer, 2014; Rietveld & Schilling, 2021), platform openness in general (Broekhuizen et al., 2021), and boundary resources (Eaton et al., 2015; Ghazawneh & Henfridsson, 2013) by contrasting paradigmatic advice. This contrast matters as the coexisting strategic management paradigms OI and RBV have not yet been contrasted in the context of platform ecosystems (Cenamor & Frishammar, 2021).

The paper is structured as follows. We first define platforms and discuss peculiarities of contexts where platforms are technological infrastructures for complement development. The following section introduces the context of the study, which is video game consoles. We then develop hypotheses on how exclusive content, boundary resources, and breadth of content offerings affect complementor participation. We present data, methods, and results. The final section discusses the findings and contributions and concludes with directions for future research.

Theoretical Background: Complementor Participation in Platform Ecosystems

Platform Ecosystems

In many industries, platform-based business models are a way to reduce complexity by sharing modules, components, and other assets (Halman et al., 2003; Scholten & Scholten, 2012) and by moving the locus of value creation outside of the focal firm's boundaries (Parker et al., 2017). Platforms offer the technological

[1] Although boundary resources are known to affect complementor participation positively, they have not been studied as representatives of the OI paradigm in comparison with the RBV.

infrastructure for developing complementary innovations by facilitating economies of scope, which is defined as reducing costs by developing two products jointly instead of separately (Gawer, 2014).

This approach to value creation can sometimes give rise to the emergence of a platform ecosystem. An ecosystem is 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). While participants have the flexibility to join multiple platform ecosystems, called multihoming (Rochet & Tirole, 2003), complementors must make platform-specific investments that cannot be easily repurposed elsewhere (Jacobides et al., 2018). These platform-specific investments explain why complementors do not necessarily offer complements on all competing platforms and why platform orchestrators must make an effort to attract complementors. Several drivers of complementor participation explain why complementors may favor one platform over the other, following the logic of OI and RBV.

Complementor Participation: Open Innovation and Resource-Based View

A reason for complementors to participate in platform ecosystems lies in the prospect of innovating on the platform (Hilbolling et al., 2020) and accessing its user base (M. Sun & Tse, 2009). The architecture of most platforms is designed in a modular way (Baldwin & Clark, 2000; Schilling, 2000). Systems of higher modularity "enable heterogeneous inputs to be recombined into a variety of heterogeneous configurations" (Schilling, 2000, p. 317). Modularity reduces complexity by splitting systems into components arranged according to a standardized architecture and connected via standardized interfaces. Modularity also reduces the scope of information designers have to work with, enabling more specialization and the division of innovative tasks (Garud & Kumaraswamy, 1995). Hence, their modular architecture makes platforms suitable for facilitating innovation (Gawer, 2014), potentially increasing complement variety and performance (Fleming & Sorenson, 2001)

Interfaces as a form of technological openness (Nikayin et al., 2013) are crucial for modularity and innovation as they simultaneously divide and connect innovative activities (Baldwin & Clark, 2000). Boundary resources such as application programming interfaces (APIs) or software development kits (SDKs) provide such interfaces (Ghazawneh & Henfridsson, 2013). Next to technological openness (e.g., accessibility of interfaces), openness can also be controlled via rules and contracts that determine whether and to what extent complementors can participate in the platform (Nikayin et al., 2013). Together, technological and organizational openness and modularity can facilitate forms of recombinant innovation (Nelson & Winter, 1982) by external parties.

An open strategy 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). Giving complementors access to the platform increases their adoption rates, leading to more diverse and innovative complement offerings (Ondrus et al., 2015). However, these benefits are dependent on the specific open platform strategy.

While OI highlights the locus of innovation potential and how to access it, the RBV provides a lens for evaluating external resources' strategic fit and leveraging them to create value. Uniquely valuable resources can but need not be under the complete control of the focal organization to form a source of value (Jacobides et al., 2012). Valuable resources under the control of the platform owner include, for instance, the technological design of the platform and technological advances across generations (Ozalp et al., 2018) or moves by the platform owner, such as protection against external threats by the platform owner (Bagheri et al., 2016). Valuable resources not entirely under the platform's control are, for instance, the ecosystem of users and complementors that complementors gain access to by joining the platform ecosystem (Jacobides et al., 2012). Such resources are especially valuable when customized or co-specialized (Davis & DeWitt, 2021), such as in the context of non-generic complementarities in ecosystems. Before building our argument on potential complementor strategies, we first introduce the empirical context.

Empirical Context: Video Game Consoles

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 (iPhone). 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).

Traditionally, the hardware specifications of consoles remain unchanged during their lifetime. However, introducing a new generation is an opportunity to update hardware and increase processing and graphical power. Technological changes in the industry have led to eight generations of incompatible video game consoles, with new generations being introduced roughly every five years (Srinivasan & Venkatraman, 2010). In this case, three main platform providers (console manufacturers) have recently been active in the industry (Lee, 2012): Nintendo, Sony, and Microsoft. This study 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.

Although competition has been fierce in each generation, this has not led to one dominant console. The success of a platform in this industry heavily depends on the platform owner's ability to attract complementors (video game developers) who produce high-quality content (video games) for the respective platform (game console). Consequently, consumers carefully consider each console's game quality and diversity when making purchasing decisions.

Three incompatible consoles competed in the seventh and eighth generations of video game consoles. Incompatibility entails that complements (video games) developed for one platform (video game console) will not readily run on another platform. Users can adopt either of the platforms or choose to multihome (buy more than one platform), involving the extra cost of purchasing another video game console. Similarly, complementors can decide to develop a game for one platform exclusively or to multihome by creating the game for more than one platform. However, multihoming requires games to be ported to other platforms, involving high costs. Most games are available for multiple platforms in a generation of video game consoles (Vjestica, 2022).

Hypothesis development

Open Innovation: Breadth of Content Offerings and Boundary Resources

Leveraging the contributions of third parties to drive innovation jointly with the platform is one reason for the success of many platform ecosystems (Jacobides et al., 2018; Nambisan et al., 2018). OI and openness of platforms are driven by *who* can participate, conceptualized as the breadth of content offerings, and *how* the interaction takes place, conceptualized as boundary resources (Gawer, 2020).

We define the breadth of content offerings as the variety of categories a platform represents via complements. Breadth refers to the number of categories (as opposed to depth, which is the number of items per category) (Broekhuizen et al., 2021). The breadth of content offerings can hence be seen as an aspect of access openness (Benlian et al., 2015). It relates to the scope of user demands the platform can cater to via complements. Consumer demands on platforms such as video game consoles are often heterogeneous, and platforms can address these demands by expanding to different complement categories.

For example, early smartphone apps were mostly productivity-related tools such as calculators, address books, and notepads. Today, smartphone apps cover all conceivable areas, including health (e.g., nutrition trackers), automotive (e.g., CarPlay), and many more. Hence, expanding the opportunities for complementors to reach different categories allows the platform to increase the strength of indirect network effects. Individual users may rely on particular likes and dislikes, creating a unique combination of frequented game title markets. 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). Giving complementors horizontal access to different genres allows them to differentiate their products. It provides them with a wider variety of content on the platform and will enable them to identify and target specific customer niches and preferences. As a result, competition decreases, compared to a platform focused on a narrower set of markets and avoiding crowding situations (Boudreau, 2012; Cennamo & Santaló, 2013).

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 genre on that platform, likely involving extra marketing costs. Hence, the breadth of content offerings, or the number of categories a platform represents, increases entry options for complementors without having to pioneer the game category on that platform. That might give the focal console an advantage over competing consoles with representation in fewer categories. Similarly, having complement offerings in more different categories might attract a more extensive variety of complementors compared to a platform with representation in fewer categories. Boudreau (2012) supports this argument with evidence from the context of mobile handheld devices. He found an increase in hardware complements when platforms gave access to many complementors from various industries to the platform. Hence:

Hypothesis (H1): *The breadth of content offerings positively affects complementor participation in a platform.*

Relying on complementors for value creation poses the challenge of designing the technology so that complementors can access the core technology without exposing too much. Boundary resources provide a demarcation point between the platform and complementors (Hein et al., 2020), and can also be seen as modules that facilitate economies of scope. In the case of video games, 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. The assortment of issued boundary resources influences the platform's openness and generativity (Ghazawneh & Henfridsson, 2013; Karhu et al., 2018; Parker et al., 2016).

The literature on boundary resources focuses on the perspective of platform owners (Bianco et al., 2014; Eaton et al., 2015; Ghazawneh & Henfridsson, 2013). Boundary resources regarding APIs and SDKs have mainly been studied to involve complementors (Eaton et al., 2015; Ghazawneh & Henfridsson, 2013; Schreieck et al., 2016). They are essential for managing the tension between securing control of the platform infrastructure and maintaining its generativity (Eaton et al., 2015; Mukhopadhyay et al., 2016). Boundary resources lower barriers to entry for new complementors (Hein et al., 2020), provide access to the platform's core resources (Baldwin & Woodard, 2009)and facilitate collaboration and value co-creation between ecosystem participants (Autio, 2022; Engert et al., 2022).

Boundary resources are of strategic value to the platform owner and require careful management (Wulfert, 2023). Platform owners can exert control via boundary resources by introducing new ones or modifying existing ones (Karhu et al., 2018). A better assortment of boundary resources allows complementors to focus more on game design and creative tasks instead of developing core technologies and making a platform more attractive for complementors. Adding new boundary resources renews the platform's innovative potential (Eaton et al., 2015) and creates new ways for complementors to interact with the platform (Kapoor & Agarwal, 2017). Regarding complements for Apple's iOS platform, Ghazawneh and Henfridsson (2013) found that the number of applications on the platform increased with every new boundary resource introduced. This suggests that boundary resources may be essential to attract complementors to the platform, as captured in our second hypothesis.

Hypothesis (H2): *The availability of boundary resources positively affects complementor participation in a platform.*

In summary, following the OI paradigm, we expect both the breadth of content offerings and boundary resources to relate to complementor participation positively.

Resource-based View: Exclusive Content

Platform owners can differentiate their complements and, hence, their platforms from rivals through exclusive high-quality or premium content (Carrillo & Tan, 2021; Hagiu & Lee, 2011). Exclusive content refers to complements only available on the focal platform (Corts & Lederman, 2009) and, hence, is a way to stand out by differentiating from others in the market (Cennamo & Santaló, 2013; Hermalin & Katz, 2013).

Exclusive content can be obtained by internally developing games based on an integrated game developer, based on a complementor's decision to offer the complement on only one platform, or via exclusive agreements with complementors. Whether to pursue exclusive contracts with complementors is a strategic trade-off for both platform and complementors.

From the *platform owner's* perspective, exclusive contracts with complementors are a way to secure unique content for end users and to enjoy the benefits of indirect network effects. When used as a strategic tool, exclusivity usually comes in exchange for a lump-sum payment or an attractive licensing fee. The platform owner must compare the prospective benefits gained from exclusive content against the cost of reducing licensing fees or lump-sum payments (Corts & Lederman, 2009). Forced exclusivity is rare in the video game industry (Lee, 2012).

From the *complementor* perspective, whether to join a platform depends on the installed base of the focal and competing platforms. The complementors' incentive to license their product to a platform depends on the market's potential, which they can reach through its installed base (Cennamo & Santaló, 2009). In this situation, with similar market shares, complementors tend to multihome to spread the fixed costs of development over several platforms (Corts & Lederman, 2009). However, multihoming is not for free as variable costs are necessary to make a complement compatible with another platform. Given the extra cost, a complementor can also offer a game on one platform only.

How much exclusive content is offered on a platform has implications for complementors. It may attract future complementors for the following reasons. Exclusive content is often of higher quality than non-exclusive content. Cennamo, Ozalp, and Kretschmer (2018) show that the quality of complements drops if complementors decide to produce simultaneously for different and technologically complex platforms. Fully leveraging the technological capabilities of a platform requires managing an increasing number of interdependencies that result in technological complexity. In the context of video game consoles, this technological complexity depends, for instance, on the number of specialized and interdependent processors. Optimally allocating tasks to processors is challenging for developers (Horowitz, 2013). More exclusive games, therefore, signal higher-quality content to future complementors.

Further, exclusive content can incentivize users to join a lagging platform over an incumbent platform (Lee, 2013). Without exclusive content, high-quality software would be released on the incumbent platform based on the prospects of selling to a larger installed base. Often, top-ranking exclusive games are the ones that sell consoles (Binken & Stremersch, 2009). Additionally, complement availability on other platforms may reduce the indirect network effects stemming from this complement (Gil & Warzynski, 2010) as it reduces the differentiation of the platform (Coughlan, 2004; Lee, 2013). Since most games are multihoming (non-exclusive) (Vjestica, 2022), a higher share of exclusive games on the focal platform increases its attractiveness to future complementors. Hence:

Hypothesis (H3): *Exclusive content positively affects complementor participation in a platform.*

Data and Methods

Data and Sample

We created a panel from multiple sources. We obtained quarterly global sales data from VGChartz. This industry research firm compiled a game database covering over 40,000 titles and 1.5 million data points, spanning two generations of consoles and game titles (seventh and eighth generation, 2005-2015). It also documents every game title's release year, publisher, developer, genre, and the platform 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). The Internet Game Database (IGDB) provides information on game engines available for each console (including release dates), validated by

cross-checking with online news and press releases. In summary, the dataset comprises six video game consoles (platforms) and two generations, during which 2199 game titles were released.

Measures

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 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)[2].

Regarding independent variables, we measure the *breadth of content offerings* as the proportion of game genres produced for platform i 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. Here, genres serve as a proxy for markets, and the availability of a game title by platform i in a specific genre is seen as catering to this market. The more genres a platform covers, the more accessible it is to different markets from the complementor perspective. We operationalize the *availability of boundary resources* as a count of game engines available for platform i in quarter $t-1$. 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 Cennamo and Santaló (2009).

We define exclusive content and breadth of content offerings 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 console 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. We use the natural logarithm of the installed base to reduce the skewness (for use in first-stage estimations). 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, consumers 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

[2] We thank an anonymous reviewer for this suggestion.

As discussed above, we seek to estimate whether the breadth of content offerings and boundary resources (OI), as well as exclusive content (RBV), 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 (J. 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.[3] We estimate the model using the maximum likelihood estimator (MLE) (Washington et al., 2020). 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.

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 (breadth of content offerings 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, increases complementor participation if this is the only game offered by this complementor. Similar concerns may apply to the breadth of content offerings. 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 the breadth of content offerings. 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 based on the costs of consoles (Clements & 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[4] 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.

[3] Both Akaike's information criterion (AIC) and Bayesian information criterion (BIC) 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.

[4] 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.

Results

Descriptive Statistics

Table 1contains 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.

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	19.41943	0	110
	between		7.38208	5.916667	26.22222
	within		18.62742	-4.128697	105.8713
Breadth of content offerings	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 ($\bar{\bar{x}}$), the summary statistic decomposes the variablex_{it} into between ($\bar{x}_i$) and within ($x_{it} - \bar{x}_i + \bar{\bar{x}}$), adding the global mean back in to make the results comparable (StataCorp, 2017). The statistics refer to installed based after logarithmic transformation.

Table 1. Descriptive statistics.

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 3457 times, indicating significant multihoming. Nevertheless, Figure 1 and Table 2 show 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.[5]

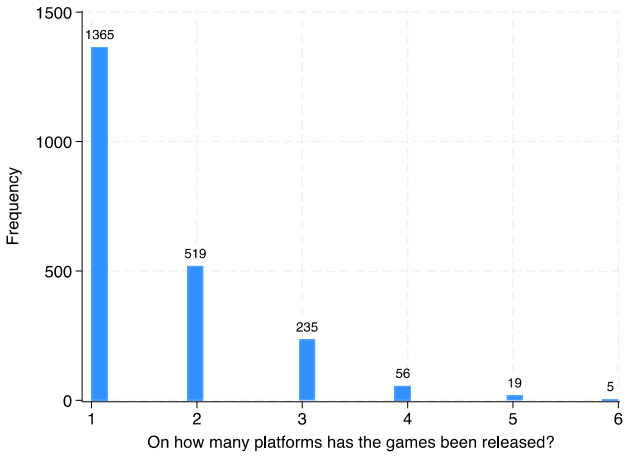

Figure 1. Multihoming games.

Number of platforms a game is released on	Game count	Percent	Cumulative
1	1,365	62.07	62.07
2	519	23.6	85.68
3	235	10.69	96.36
4	56	2.55	98.91
5	19	0.86	99.77
6	5	0.23	100
Total	2199	100	

Table 2. Multihoming games.

Main Results

We present the results in Table 3. We rely on conditional fixed-effects negative binomial regressions to estimate the effect of boundary resources, breadth of content offerings, and exclusive content all positively affect complementor participation (in its two definitions). In Model 1, complementors is the dependent variable, games in Model 2. The models with platform and year fixed effects achieve the best fit across both definitions of the dependent variable.[6] Hypothesis 1 states that the breadth of content offerings positively affects complementor participation. However, its coefficients are insignificant across most models and do not support the hypothesis. Hypothesis 2 states that the availability of boundary resources positively affects complementor participation. The results support this hypothesis based on positive and highly significant coefficients across all models. Hypothesis 3 argues that exclusive content positively affects complementor participation—the coefficients for exclusive content are highly significant and positive across all models, supporting our argument.

[5] We thank an anonymous reviewer for pointing this out.

[6] Estimations with quarterly fixed effects lead to very similar conclusions based on comparable coefficients and significances, although with worse fit (based on AIC and BIC).

The control for the installed base has a positive and significant coefficient on joining new complementors, and it has no significant effect on new game releases. 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. 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. Seasonality has a positive and significant coefficient, with a higher coefficient in the models estimating new game releases. 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.

To summarize, we reject H1 (related to breadth of content offerings) but confirm H2 (related to boundary resources) and H3 (related to exclusive content). In other words, boundary resources and exclusive content positively relate to complementor participation. However, contrary to our argument, the breadth of content offerings is unrelated to complementor participation. The findings regarding boundary resources align with Ghazawneh and Henfridsson (2013), who attribute a prominent role to boundary resources in complementor attraction. Further, our findings stress the positive impact of exclusive content in attracting new complementors. This finding resonates with Lee (2013), who shows that an industry without exclusive content may reinforce the incumbent's leading position as exclusive content incentivizes consumers to multihome. Our findings show that exclusive content increases the attractiveness of a platform to complementors, compared to a platform with less exclusive content. However, we do not find support for the previous research that emphasizes the importance of a diversified complement portfolio (Boudreau & Jeppesen, 2015; McIntyre et al., 2020).

	(1)	(2)
	Dependent variable: complementors	Dependent variable: games
	Negative binomial fixed effects regression	Negative binomial fixed effects regression
Installed base	0.341***	0.00966
	(0.116)	(0.0271)
Generation	0.188	-0.403**
	(0.247)	(0.186)
Seasonality	0.389***	0.636***
	(0.0648)	(0.0588)
Breadth of content offerings	0.152	0.0229
	(0.267)	(0.245)
Boundary resources	0.116***	0.110***
	(0.0204)	(0.0181)
Exclusive content	1.357***	1.247***
	(0.259)	(0.245)
Fixed effects	Platform, Year	Platform, Year
Log-pseudolikelihood	-309.957	-395.6
AIC / BIC	649.9 / 693.9	821.1 / 865.1
Obs., platforms	139 /6	139 /6
Note. Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.		

Table 3. Second-stage regression results (fist-stage reported in Table 4).

The findings demonstrate that drivers from both OI and RBV are relevant for complementor participation. Seeing the 'open' in OI, one might insinuate that OI is more applicable to contexts such as platform ecosystems, where value creation explicitly transcends organizational boundaries. Traditionally, RBV research has focused on studying the impact of a company's internal resources or capabilities on value creation (Lavie, 2007). However, neither OI nor RBV are theories of organizations, nor are they confined to organizational boundaries. They are theories of how productive resources can be utilized to generate economic returns and center on attributes of these resources that strengthen or perpetuate these returns (Davis & DeWitt, 2021). This means that alternative forms of organizing, or meta-organizational forms of organizing, are also characterized by VRIO (Barney, 1991), and it cannot be concluded ex-ante that the RBV is less relevant in 'open' contexts. This argument corresponds with recent integrations of the RBV with ecosystem theory (Gueler & Schneider, 2021).

Discussion and Conclusion

This research paper examined drivers of complementor participation derived from two influential paradigms in information systems research, OI and RBV. We contrasted these paradigms by studying drivers of complementor participation representative of the OI and RBV paradigms. Specifically, we examined how the breadth of content offerings, boundary resources (OI), and exclusive content (RBV) affect complementor participation. 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 drivers from both OI and RBV (boundary resources, exclusive content) affect complementor participation.

Contributions and Implications

The paper offers several contributions. First, it adds to the growing literature on how the platform hub federates and orchestrates an ecosystem of complementors (Rietveld & Schilling, 2021), responding to calls for research on the drivers and consequences of changes in platform openness (Gawer, 2014) by identifying drivers for complementor participation. It also contributes by testing these drivers, which has rarely been studied to date (Broekhuizen et al., 2021). Second, it contrasts two ways of explaining complementor participation using concepts from the OI and RBV paradigms. Thereby, it effectively bridges these two paradigms and responds to calls to integrate the RBV with other paradigms (Arend & Lévesque, 2010). Our results suggest that both the OI and RBV paradigms are relevant in complementor participation. Third, we contribute to the measurement and dimensionality of platform openness by suggesting measures for the breadth of content offerings and boundary resources – something scholars still need to agree on (Broekhuizen et al., 2021). Previous approaches to studying boundary resources were primarily qualitative (Ghazawneh & Henfridsson, 2013; Karhu et al., 2018).

The results can guide platform orchestrators on how to increase complementor participation. In practice, relations with complementors require nourishing and cherishing. Studying both the intensive and extensive margin of complementor participation, our study helps practitioners create and maintain a diverse ecosystem of complementors. Particularly, we argue for exclusive content as a driver of complementor participation. The findings show that exclusive content can be used strategically to attract complementors.

Limitations and Future Research

Several limitations apply. First, generalizability may be affected by the specifics of the video game context. In contrast to the video game industry, mobile phones based on Android and iOS do more or less entirely without exclusive content, and multihoming is common among developers (Hyrynsalmi et al., 2016). A potential explanation is that multihoming is inconvenient for users, and most would find carrying more than one phone cumbersome. Not so in game consoles - although multihoming is expensive (the cost of an additional console), it is, in principle, workable as video game consoles are not portable devices. Hence, exclusive content can only attract future complementors to the extent that it is essential in the platform market.

Second, while focusing on complementor dynamics, our data reflect video gaming platforms and interconnected 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 platforms classes (consoles, handheld devices, PCs).

Third, 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 breadth of content offerings. 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 (Zapadka, 2022)) are likely not independent of the current study's frame of boundary resources.

We see promising future research directions. First, OI and RBV could be contrasted based on more targeted measures of complementor participation, such as attracting especially productive, successful, or innovative complementors. Second, exclusive content, representing platform distinctiveness in RBV, could be refined by distinguished by type, such as in-house, third-party exclusive, or particularly successful and highly-ranked exclusive titles (Castro & Sant'Anna, 2023). Third, Cennamo et al. (2018) show that complex consoles have more complements in the top 10 than simpler platforms. Future studies could introduce platform sophistication as an aspect of platform distinctiveness in RBV. Lastly, future research could address which drivers affect complementor participation effectively in terms of the costs incurred to address them.

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Appendix

Table 4 contains first-stage regression results. We estimate the first stage with ordinary least squares and the fixed-effects specification. We started by regressing all independent variables and controls and one exogenous variable on the installed base. We then retained only significant variables in the model. The model used for the predictions is the parsimonious model, including the exogenous variable (exchange rate), breadth of content offerings, generation, and seasonality. The predictions for the installed base are then included in the second stage of the model.

Variables	(1)	(2)
	Dependent variable: Ln installed base	Dependent variable: Ln installed base
Exchange rate	17.45**	17.45**
	(7.037)	(7.037)
Breadth of content offerings	2.387***	2.387***
	(0.267)	(0.267)
Generation	-1.121***	-1.121***
	(0.154)	(0.154)
Seasonality	-0.414***	-0.414***
	(0.110)	(0.110)
Constant	10.90***	10.90***
	(0.920)	(0.920)
Number of observations / platforms	139 / 6	139 / 6
R-squared	0.709	0.709
Note. Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1		

Table 4. First-stage regression results corresponding to Table 3.