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How do entrepreneurs create indirect network effects on digital platforms? A study on a multi-sided gaming platform

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ABSTRACT

Digital platforms play a central role in today's market-based competition. To build a successful platform, entrepreneurs must pursue indirect network effects and shape multiple sides of the platform. However, the extant literature provides only a meager understanding of how entrepreneurs can create such indirect network effects. To better understand how this can be done, we conduct a case study that longitudinally traces 16 years of digital game platform growth as the entrepreneurs bring the platform successfully into multiple markets. The analysis advances theorising of the entrepreneurs' repertoires of moves seeking to increase the number and variety of platform participants conducive to creating indirect network effects. The findings indicate that early moves focus on creating technical solutions that overcome technical challenges and permit platform scaling, whereas later moves seek to create a more flexible and generalisable platform architecture that allows a wider range of interactions. The findings make several contributions to the digital entrepreneurship literature by synthesising a dynamic model of entrepreneurs' repertoire of competitive moves that will induce indirect network effects.

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1. Introduction

Contemporary digital technologies shape deeply entrepreneurial opportunities and actions (Nambisan 2017; Yoo et al. 2012). In particular, the emergence of digital platforms has transformed the field of entrepreneurship and how entrepreneurs bring innovations to the market (Nambisan 2017). Platforms, such as video and music platforms, form multi-sided markets that allow service providers and users to transact and exchange value. To compete successfully in these markets, entrepreneurs must constantly innovate the platform and extend its services to create indirect network effects and advance platform growth and scaling (Afuah 2013). Generally, the value of using the platform on one side depends on the number or variety of participants using it on the other side – thus, the presence of 'indirect effects' (Evans 2009; Parker, Alstyne, and Choudary 2016). Service extensions are expected to create positive network effects on the same or other side of the platform (de Reuver, Sørensen, and Sasole 2018; Parker, Alstyne, and Choudary 2016; Rietveld and Eggers 2018; Tiwana, Konsynski, and Bush 2010).

In practice, creating and orchestrating indirect network effects has remained a challenging proposition (Parker, Alstyne, and Choudary 2016, 2017; Pellizzoni, Trabucchi, and Buganza 2019; Tura,

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Kutvonen, and Ritala 2018). Entrepreneurs are expected to constantly innovate new features on the platform that will lure and make it easy for platform participants to provide complementarities in the form of new platform modules and services that will push for new participants on the other side (Yoo, Henfridsson, and Lyytinen 2010). However, the question of how entrepreneurs can initiate and grow indirect network effects on their platforms is complex and remains poorly explored. Most available accounts on the topic, although valuable and illuminating, are mainly personal after-the-fact rationalizations of the success of now-dominant platforms such as Facebook, Amazon, or Google (see, e.g. Simon 2011). Most academic studies on platform growth (see, e.g. Evans and Schmalensee 2016; Parker, Alstyne, and Choudary 2016) use economic models to explain how indirect network effects 'operate' when a critical mass has already been achieved on the platform (Rochet and Tirole 2003). We know less about how entrepreneurs initially create mechanisms that scale the platform and thus cumulatively produce indirect network effects over time (Arthur 1989). In particular, we know little about how entrepreneurs *in situ* orchestrate a digitally feasible platform architecture and shape its offerings over time to create such effects (Afuah 2013; de Reuver, Sørensen, and Sasole 2018; Nambisan 2017). Consequently, we ask: *How do entrepreneurs orchestrate mechanisms that over time engender indirect network effects on a digital platform?*

Given the paucity of research on the topic and the lack of theory and empirics, we conduct a longitudinal case study of entrepreneurs' actions to create indirect network effects (Eisenhardt 1989; Yin 2009). To this end, we examine a representative case in which entrepreneurs build a multi-sided gaming platform over a 16-year period that shows such effects. In particular, the objective of this study is to analyze and identify a repertoire of entrepreneurial actions that can inch the platform toward indirect network effects. These actions in platform architecture and design manifest or engender interactions between past and present architectural decisions about a layered modular architecture of the service (Yoo, Henfridsson, and Lyytinen 2010). From a theoretical point of view, we treat platform growth as a form of effectuation, in which the entrepreneur engages in a string of local and incomplete actions that have short- and long-term effects and intended and non-intended effects. Effectuation is characterised by situatedness, ambiguity, and uncertainty (Alvarez and Barney 2010; Sarasvathy 2001, 2008). We view creating indirect network effects as a path-dependent (Arthur 1989) and equifinal process. It is open to multiple pathways and operates under plausibility; at any point in time, only a limited set of action paths are plausible (Abell 2004). The idea of a path-dependent set of plausible pathways invites us to examine what enables and/or constrains entrepreneurs' action repertoires in creating such indirect network effects (Gawer 2009; Tiwana, Konsynski, and Bush 2010).

The remainder of the paper is organised as follows. In Section 2, first, we review the literature to identify various network effects; second, we introduce the concepts of competitive moves and effectuation; and third, we examine the notion of a layered modular architecture. In Section 3, we present the research design and method. In Section 4, we present the findings of the longitudinal case study. In Section 5, we present a process model for increasing the indirect network effect and conclude the study by noting the contributions, practical implications, and avenues for future research.

2. Literature review

2.1. Indirect network effects on multi-sided platforms

The creation and management of positive indirect network effects form a critical and formidable task for any early-platform entrepreneur (Afuah 2013; Evans 2009). An entrepreneur's efforts will ensure the continued growth of and value extraction from the digital platform. If and when such effects are created, the platform will reach a critical mass of users (Armstrong 2006; Eisenmann, Parker, and Van Alstyne 2006; Rochet and Tirole 2003). Therefore, the entrepreneur needs to continuously invite and lock in participants on all sides of the platform to create indirect network effects. Moreover, with the presence of indirect network effects, the different 'sides' of the user network are expected to *mutually* benefit from the size and characteristics of the other side (McIntyre and Srinivasan 2017).

The value of indirect effects for participants does not result solely from the number of users on each side but also from how much participants on each side add value in a variety of complementarities on the other side (Afuah 2013; Karhu, Heiskala, and Ritala 2020).

Because of the different natures and complexity of these interdependencies, scholars have suggested that several factors shape indirect effects (Afuah 2013; Karhu, Heiskala, and Ritala 2020). We identify four such factors. First, indirect effects are typically created by having at least a sufficient variety of complements on one side (e.g. games, music, movies, and books; Evans 2009). Second, these effects can be created by providing development tools to create new complements or by decreasing control over the platform's content or functions (Boudreau 2012). Third, skewed pricing structures may be needed to support one side in growing a large enough participant pool (Armstrong 2006; Rochet and Tirole 2003). Fourth, complex dependencies among other components on the same or different sides help create cross-side value (Evans 2009; Karhu, Heiskala, and Ritala 2020).

However, although the four factors can have an effect, their treatment thus far has several limitations. First, most studies have applied static economic analyses to detect such effects (Armstrong 2006; Evans and Schmalensee 2016; Rochet and Tirole 2003). Second, when dynamic analyses are constructed, they are presented as after-the-fact cases to show how the indirect network effects operate (Evans 2009; Parker, Alstyne, and Choudary 2016). Third, the studies mostly conceptualise the launch of a digital platform with a critical mass as a single event (Evans and Schmalensee 2016) and ignore the crucial role of entrepreneurs in cumulatively garnering such indirect network effects (cf. Parker, Alstyne, and Jiang 2017). To wit, most studies have not probed the origins and logic of creating indirect effects, but instead have mainly focused on the number of users on either side (Karhu, Heiskala, and Ritala 2020; Trabucchi, Buganza, and Verganti 2021). Fourth, previous analyses have examined well-established, successful platforms (Boudreau 2012; Karhu, Gustafsson, and Lyytinen 2018; Parker, Alstyne, and Choudary 2016). In contrast, the launch of 'start-up' platforms has received less scholarly attention (Evans and Schmalensee 2016).

2.2. Creating indirect network effects through competitive moves

Explaining how entrepreneurs achieve indirect network effects on a multi-sided platform calls for an accounting of their actions (Sarasvathy 2001, 2008). On digital platforms, effectuation, by nature, concentrates on how entrepreneurs and third parties create platform services over time and what features characterise the success of their actions in promoting indirect network effects (Nambisan 2017). To narrate ongoing effectuation, we need to analyze entrepreneurs' cognition and autonomy, which ultimately drive their opportunity recognition and realisation (Alvarez and Barney 2010; Sarasvathy 2001, 2008).

Generally, entrepreneurs effectuate indirect network effects through a series of moves that they expect to have a positive impact on the platform's services, the number and type of users, or the platform's market position (Rietveld and Eggers 2018). Such moves are preceded by shifts in the entrepreneur's cognition and reasoning. The shifts take place as the entrepreneur learns environmental cues and feedback that include technology trends, user responses, market changes, etc. Based on this reasoning, an entrepreneur adjusts the platform's services and structure. These adjustments consider the observed value of past changes and whether the changes align with the targeted participants' preferences (Alvarez and Barney 2010; Sarasvathy 2001, 2008). Because of the high levels of ambiguity associated with effectuation, an entrepreneur's experiences often fail to provide valid causal attributions from which to choose proper actions. Therefore, identifying and abstracting the entrepreneur's activities helps formulate typologies of favourable actions. Treating classes of activities and their sequences allows us to interpret effectuation as a series of competitive moves (Chen and MacMillar 1992). These moves can be either proactive – intended to surprise *ex ante* and thus to improve the platform's position (e.g. new services) – or reactive – where the move responds to an external threat (i.e. a hostile move by other platforms or complementors; Chen and MacMillar 1992). Moreover, some moves are initiated in response to an immediate

competitive need, while other moves take place during pre-market stages or seek to resolve internal inefficiencies (Woodard et al. 2013).

2.3. Moves as bindings across a layered platform stack

Digital platforms are generally organised into a network-shaped modular architecture (Yoo, Henfridsson, and Lyytinen 2010). Accordingly, in the majority of cases, the entrepreneur's moves modify and reorganise the platform's architecture, which then shapes the scope, content, and form of platform participation. Therefore, in terms of the action repertoires available to induce indirect effects, the entrepreneur needs to engage in moves that manipulate the platform's service stack (Eisenmann, Parker, and Van Alstyne 2006). The architecture of this stack has been canonically portrayed for some time as a layered modular structure comprising four elements: (1) the device layer, (2) the network layer, (3) the service layer, and (4) the content layer (Yoo, Henfridsson, and Lyytinen 2010).

The device layer refers to the physical devices with which users operate and interact with the platform. This layer consists of hardware devices that allow users to use a platform's service offering, such as a computer, digital television, or gaming console. The network layer consists of networking protocols that govern communications between the platform, other platforms, and devices. The service layer captures the functionality of applications, specifying the services that the platform offers to all participants and enabling them to interact with the platform. The content layer covers the content that users interact with, such as financial news, games, or videos (see Yoo, Henfridsson, and Lyytinen 2010).

To provide any valuable service, the platform entrepreneur needs to 'bind'[1] all these layers of the stack to a 'complete' executable service in a specific setting. Ultimately, the entrepreneur's decisions change the configuration of the stack and influence the content and scope of the platform services. The layered architecture concept also posits that the connections between layers and within layers (modularity) are *loosely coupled*. Some components in a layer can have multiple bindings with the components or interfaces of layers above and below it. This feature creates the network type of organisation for modular layered architecture (Lyytinen, Sørensen, and Tilson 2017; Yoo, Henfridsson, and Lyytinen 2010). As a result, entrepreneurs can add or remove bindings in any platform stack so that multiple dynamic, network-shaped design hierarchies can be instantiated on the same platform stack. Because of the loose coupling, entrepreneurs cannot predict how their moves influence how the platform will evolve in the future (Yoo, Henfridsson, and Lyytinen 2010).

To facilitate innovation in the service and content layers of the platform stack, entrepreneurs seek to offer easy and cost-effective access to the content and/or the services that incentivize participants to produce complements (Prügl and Schreier 2006). To accomplish this, the entrepreneur conveys additional supply-side assets, commonly referred to as boundary resources (Karhu, Gustafsson, and Lyytinen 2018). Such boundary resources include content repositories, application programming interfaces, and software development kits (SDKs; Karhu, Gustafsson, and Lyytinen 2018; Yoo et al. 2012). Entrepreneurs can also manipulate the stack by expanding the bindings on the network and device layers, and thus offer platform services across multiple devices or networks. This strategy is commonly referred to as 'multihoming'. It is motivated by the desire to grow the user base and, as a result, gain access to new or cheaper content (c.f. Cennamo, Ozalp, and Kretschmer 2018; Rochet and Tirole 2003).

3. Research method and setting

3.1. Study aims and sampling

We selected the case study method because it enables an in-depth investigation of complex phenomena (such as platform evolution) and captures cause-and-effect relationships (such as competitive moves that engender indirect network effects; Pettigrew 1990; Yin 2009). Specifically, we

conducted a longitudinal, exploratory case study that offered a way to provide an empirically rich and detailed account of this understudied phenomenon for further theory development (Edmondson and McManus 2007; Yin 2009). Moreover, the exploratory approach provides needed flexibility when a study focuses on dynamic processes (Swanborn 2010). We were specifically interested in entrepreneur moves that promote indirect network effects, and they can be observed and accounted for only by assuming a sufficiently long-time horizon (de Reuver, Sørensen, and Sasole 2018). The chosen unusually long study period (about 16 years of platform evolution) helped capture the more validly locally emergent cause-and-effect logics that underlie an entrepreneur's actions.

The sampled gaming platform, G-cluster (established in 2000), is one of the leading cloud gaming platform providers globally (Tiwari 2015). The platform allows players to play high-quality, cloud-based video games using the Internet; the games are offered by a large set of complementors (game developers). This solution differed from the then-dominant market solutions, which offered 'boxed' gaming solutions by integrating the service into a dedicated device (e.g. Microsoft's Xbox or Sony's PlayStation). In such a solution, the device is fixed with the service, while the network solutions and content vary. The study context – the gaming industry – offers a rich setting for examining platform strategies because in this industry, platform strategies are a competitive necessity (Cennamo, Ozalp, and Kretschmer 2018; Eisenmann, Parker, and Van Alstyne 2006; Rochet and Tirole 2003).

3.2. Data collection

The data collection includes the entire history of the firm and its platform operations from 2000 to 2015.[2] The most important data source comprises in-depth interviews with the entrepreneurs who founded the firm. These interviews took place frequently and over an extended period – between 2005 and 2018 – at their research and development (R&D) unit (in Espoo, Finland) and at the firm's headquarters (in Tokyo, Japan). The firm is still relatively small, with 10–50 employees during the period. The interviewees were selected based on their knowledge of different phases of the platform evolution, technology, and markets (see Table 1). We used open-ended thematic questions that evolved during the study process. The first interviews (in 2005) focused on the history of the firm with respect to the creation of the platform and its initial development. Thereafter, each follow-up interview focused on the platform and business development and was tailored based on the interviewee's role and responsibilities in the firm. In addition to G-cluster's employees, we conducted interviews with three employees of the firm's partner in Tokyo to more fully understand the development activities for the platform. Altogether, the data corpus includes 31 interviews, each 45–90 min, with an average length of 60 min. All interviews were recorded and transcribed verbatim, resulting in 339 single-spaced pages of interview data.

We used face-to-face interviews as the main source of data collection due to their intimacy. Telephone and email communications were also used between the interviews to clarify inconsistencies and to seek clarification whenever necessary. After each interview, we sent a complete transcript to the interviewee to check for accuracy. In some cases, the interviewees provided minor comments or clarifications related to particular wordings or facts. To avoid retrospective bias and to validate the interview data, we collected about 180 pages of secondary data covering the entire history of the firm between 2000 and 2015.

3.3. Data analysis

Inductive comparative techniques were applied to analyze the data corpus (Eisenhardt 1989; Miles and Huberman 1994). First, we reduced the data (Miles and Huberman 1994) by synthesising the transcripts and the secondary data (Eisenhardt 1989) into a baseline narrative that presented a chronological history of events influencing G-cluster and its platform (Pettigrew 1990). Second,

Table 1. Interviewees.

Person interviewed	Interview date (month/year)	Interview length (hour/minutes)	Knowledge shared
Founder/CEO	05/2005	1:30	Business idea
	09/2010	1:30	Establishment
	10/2010	1:10	Global business development
	05/2011	1:00	Content acquisition
	12/2012	0:55	Platform evolution
	08/2013	1:00	
	05/2014	0:55	
	05/2015	1:25	
	09/2015	0:45	
	01/2016	0:55	
	05/2016	1:15	
CEO, Japanese Operations	11/2005	1:20	Corporate acquisition
			PC and IPTV market in Japan
			Platform development for the Japanese market
Software Developer	10/2010	0:50	Client software
			Porting
			Platform evolution
Vice President, Software Engineering (CEO since 2017)	10/2010	0:45	PC and IPTV markets
	05/2016	1:10	Cable TV market in the US
	12/2016	1:00	SDK, quality assurance
	10/2017	1:00	Technical issues
	10/2018	0:55	Platform evolution
Chairman, Board of Directors	11/2010	0:50	General business development
	09/2013	0:55	Business and platform development in Japan
			IPTV market development
Executive Director, Corporate Planning	11/2010	1:00	Content acquisition
			Business development in Japan
General Manager, Technical Development	11/2010	0:55	IPTV markets
	09/2013	0:50	Exclusive content development
	10/2015	1:00	Cooperation with TV manufacturers
			Mobile game markets
General Manager, Global Management*	11/2010	1:05	Cloud gaming console
	10/2015	0:50	Global market development
			TV manufacturers
Previous CEO (2000–2002)**	04/2013	1:00	Early business and platform development
			Content acquisition for demos
			IPTV pilot in the UK
Financial Controller	08/2013	1:05	Background information of the firm
	01/2016	1:00	Reports and brochures
			Daily activities
General Manager, Business And Legal Affairs*	09/2013	0:45	Content licensing
Executive Director, Home Entertainment Group*	09/2013	1:00	Content acquisition
			Content delivery
			Cloud gaming console

*Interview with a partner's employees.

**The previous CEO worked at G-cluster between 2000 and 2002 as the CEO. During the same period, the founder (and current CEO) worked as the CTO at G-cluster. He was involved in all the important decisions related to the platform and its development.

we coded the interview data for each event using open thematic coding (Strauss 1987). We identified the next stages in the platform evolution by coding data expressing the entrepreneurs' actions toward select layers of the platform stack (Yoo, Henfridsson, and Lyytinen 2010). Third, we recorded changes in binding across layers in each competitive move. For example, when an interviewee noted, 'We have had SDK in our internal use for years, but we have offered it to game developers since 2010', the SDK component was coded as a new service at the service layer that changed related bindings within the platform stack.

Next, we organised the coded patterns of the stack changes into a chronological sequence, presenting a temporal series of changes in the bindings in the stack and covering the evolution of the platform. Thereafter, we sought to identify local and situated reasons for each move by analyzing and coding the case data (Woodard et al. 2013). We derived such rationales primarily from the interview data, although the platform stack occasionally evolved without an explicit announced change in firm strategy. Through this analysis, moves can be formulated as detectable, 'signaled' moves initiated by entrepreneurs as a response to changes in technology, operations, or market opportunities to promote indirect network effects. By using this coding scheme, we established a causal connection between the entrepreneurs' move, the change in the platform stack, and the outcome in terms of growth in participation or complementarities on different sides of the platform.

4. Case study findings

Figure 1 summarises how the stack bindings evolved during G-cluster's evolution and which actors were connected, removed, and modified during the platform orchestration. The figure is based on the case narrative that is available as an online Appendix. The years in the figure indicate the objective time and how it relates to meaningful time (events) in the effectuation process. Dark boxes illustrate the target layers of the moves, and the light boxes are the influenced connected layers. If no change took place, the layer is shown as white. Figure 2 depicts the platform's growth in terms of the number of games offered (supply-side growth). Figure 3 shows the number of delivery channels, which can be used as a proxy for the demand-side (user) growth potential.[3]

The platform evolution included six types of competitive moves by the firm's entrepreneurs. Generally, the moves fit into three broad categories based on the intended effect: (1) *initial binding*, (2) *change binding*, and (3) *modifying binding properties.* These categories differ in terms of how the moves within each category configure the stack. The competitive moves are defined with their distinct differences, with examples in Table 2.

The *initial binding category* includes the initial first move, which *launched* the platform. The move introduced the first 'full' platform stack. It was motivated by the entrepreneurs' vague perceptions and assumptions about the future service and their understanding of the technical capabilities that permit the platform stack to be configured. In this case, these possibilities involved playing games while being mobile and reaching a new mass market. In 2000, G-cluster's entrepreneurs imagined that the initial service would be built around the 'hot' 3G mobile networks and would create an

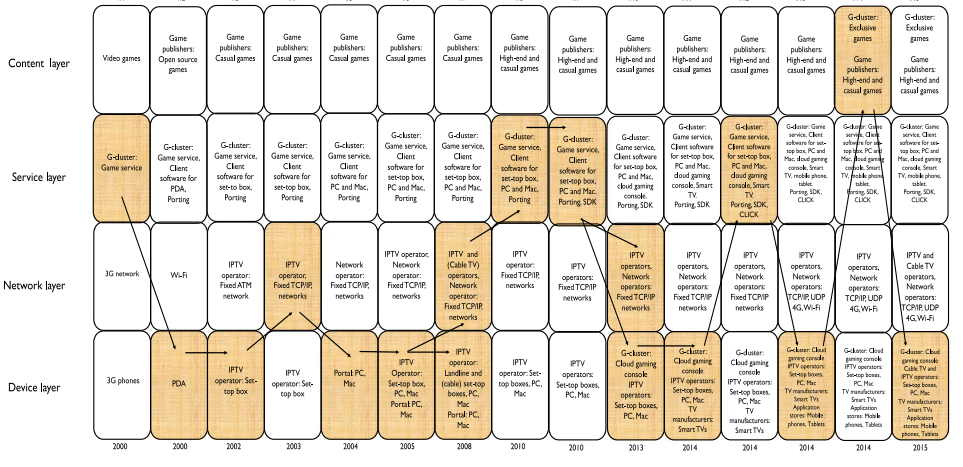

Figure 1. Evolution of the platform stack.

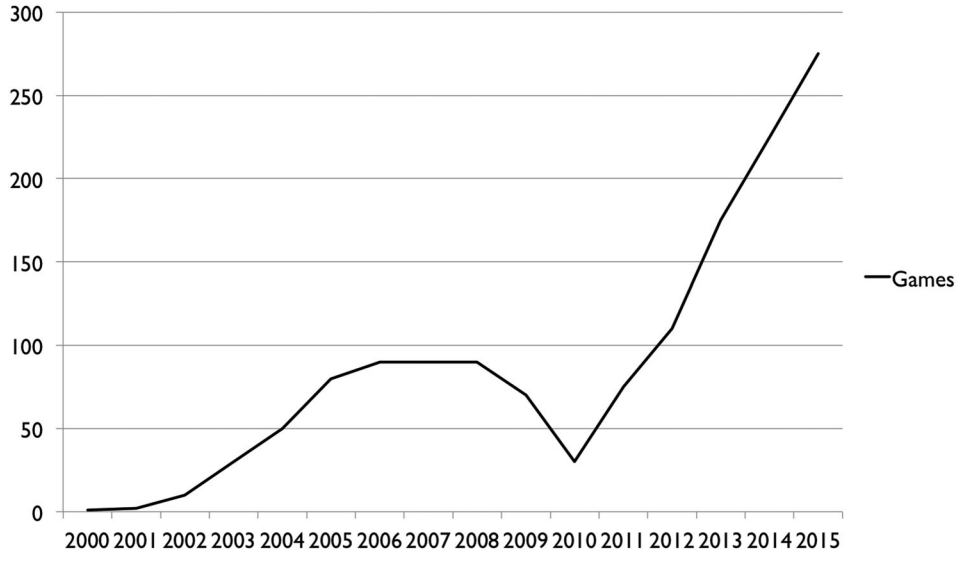

Figure 2. Number of games available through the service.

unprecedented mobile gaming experience. Based on this, they started to develop a gaming platform for 3G networks and devices, although they were highly uncertain about how they would orchestrate a feasible platform stack. The first bindings failed, illustrating that the entrepreneurs' initial conjectures were false. The vice president (software engineering) explained,

> We realized quite soon that 3G networks are not fast enough for this service. However, we knew that this service also works on other networks. That is why we thought that IPTV was a new and promising technology that we could aim next.

Such failures are typical during the early development of multi-sided digital platforms. Overall, technical feasibility is necessary to have indirect network effects, but it does not guarantee such effects.

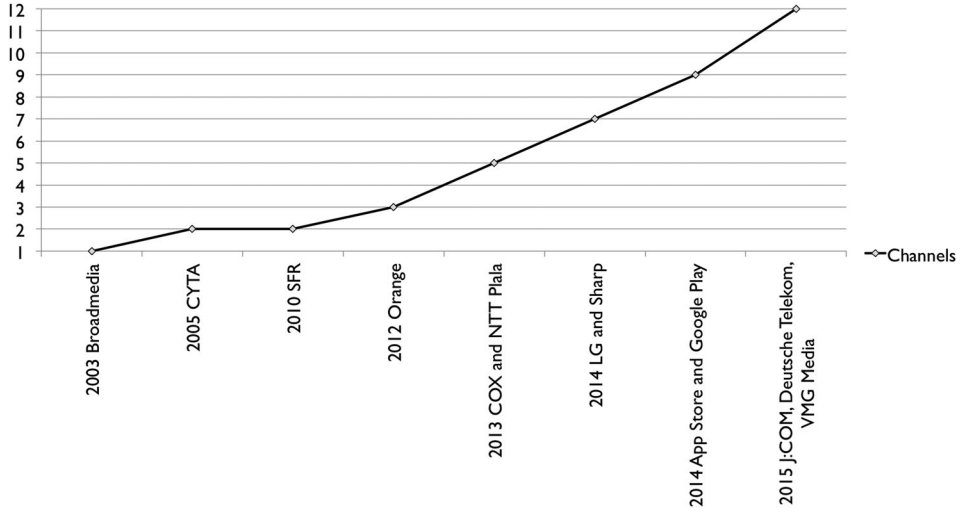

Figure 3. Number of delivery channels.

Table 2. Competitive moves in the G-cluster case.

Competitive move	Definition	Sequence	Category	Rationality	Aim and impact(s) on the network effects	Example from the case findings
Launch	The move when there is no existing binding. Suggests the first combination for the designed platform stack	First move	Initial binding	See how the designed combination of layers works in a real-life setting. Design architecture goes live, and the entrepreneurs can see the functionality of the designed architecture and develop a business model around it	Technical feasibility generally makes indirect network effects possible. Although the platform works from a technical point of view, no indirect network effects are guaranteed as such	Entrepreneurs brought the idea of a cloud gaming platform for 3G mobile phones to the market. Entrepreneurs built an architecture that would, in theory, be able to run the service
Substitute	Replaces an existing module or actor in a chosen layer (s)	Can be used after the *launch* move	Change bindings	If the functionality of the module or the service provided by an actor is not sufficient or capable of running the service, it has to be substituted or replaced with a new, better solution	Increases indirect network effects, improving reliability by replacing less workable solutions at the device and network layers. The extent to which the new binding affects indirect network effects directly remains uncertain. Simultaneously increases the complexity of the platform	Development and reliability of IPTV services were uncertain in 2003; thus, the entrepreneurs used a substitute for IPTV set-top boxes, moving to the PC and Mac markets that provided mature technology to bring the service to the market
Multihome	Extends access to the service through different devices and/or networks controlled by third parties	Can be used after either the *launch* or the *substitute* move	Change bindings	Facilitates users' access to the service by providing alternatives for getting into the service	Increases indirect network effects by providing complements that extend access to the platform at the device and network layers. Increases the complexity of the platform and decreases control over the device and network layers	When enabling technology was developed further, the entrepreneurs multihomed their gaming service to different devices, such as IPTV set-top boxes and 4G mobile phones. Furthermore, they multihomed the service via different networks, including IPTV networks and 4G networks
Bypass	Bypasses control and/or the dominant position of an actor/actors by bringing own resources to a certain layer of the platform stack	Can be used after the *launch* or *substitute* move	Change bindings	To achieve a stronger position and control in the platform stack, a firm can expand its control to other strategically important layers of the platform stack	Increases direct and indirect network effect at network, device, or content layer by improving reliability and diversity. Direct network effects emerge only if the service attracts multiple players to join multiplayer games. Adds competitive position with regard to other devices or content providers	The entrepreneurs developed a cloud gaming console for G-cluster to bypass the dominant role of IPTV operators at the network layer

(*Continued*)

Table 2. Continued.

Competitive move	Definition	Sequence	Category	Rationality	Aim and impact(s) on the network effects	Example from the case findings
Facilitate	Makes bringing content to the service easier by providing software tools to content providers	Can be used after the *launch* or any other move	Modifying binding properties	By facilitating content acquisition for the platform, a firm can expand its offerings to users and make the platform more attractive	Increases indirect network effects through diversity and through quality content by providing third parties with easy access to the platform for content augmentation. If not properly controlled, might lower content quality, which decreases players' interest and decreases indirect network effects	The entrepreneurs provided tools, such as SDK, for content providers to facilitate content acquisition
Constrict	Constricts the service offerings by increasing standardisation and making them less complex	Can be used after the *multihoming* or *bypass* move	Modifying binding properties	If the complexity of the service increases, a firm has to constrict its offering to better manage the platform and bindings around it	Increases indirect network effects through trust when reputable and valuable content providers and delivery channels join and when simplified stack layers have been created to standardise the platform. Might decrease indirect network effects if innovative but smaller content providers cannot update their content for a new platform version	The entrepreneurs reduced the number of different versions of the platform and then provided only one standardised version

Consequently, even a successful *launch* never automatically leads to indirect network effects. Instead, the launch initiates a trial-and-error search to remove any possible technical challenges.

The second move category, *change binding,* covers three types of competitive moves: substitute, multihoming, and bypass. Each move addresses specific technical and strategic problems that are often identified after the launch. Any of these moves can appear after *launch*, because as the next step, the platform owner needs to identify at least one 'plausible' set of bindings that generates enough value so that a two-sided market starts to emerge. Thereafter, when a plausible solution is found, a broader set of conditions can be satisfied by a sequence of additional moves that will inch the platform toward critical mass (Evans 2009; Parker, Alstyne, and Choudary 2016). In principle, any of these three types of moves can be deployed after the launch. The sequence of the following moves varies and depends on, among others, such factors as the type of platform service and its features and how indirect effects emerge with the service, the rate of technological innovation at different levels of the stack, the maturity and cost of the infrastructure, the market structure and growth, and the regulatory environment. In this category, the first move that G-cluster's entrepreneurs deployed was a *substitute*. This move created a 'feasible' device and network layer combination that effectively reached a large enough group of users to attract new content providers. However, estimating how these bindings will influence the growth of indirect network effects is difficult, especially with new and uncertain technologies. Based on the findings, the G-cluster entrepreneurs created a growing family of bindings at the network and device layers by accomplishing substitute moves treated as a form of experimentation. They continued substituting until a feasible platform stack was implemented that offered real potential to engender indirect network effects. When this move was accomplished, the entrepreneurs demonstrated that they had overcome technical challenges and had enough content and users that indirect effects emerged.

After overcoming technical challenges using *substitute* moves, the G-cluster entrepreneurs engaged in a series of *multihoming* moves. They increased the platform's value by enabling access to the content from new devices and networks. The CEO explained multihoming as follows:

> In the previous situation, we were able to sell our services only via IPTV operators. However, this limited our customers to IPTV users. That is why we developed a cloud gaming console that can be used over any broadband network.

As the platform services became available in new markets that offered a wider user base, the platform could now also attract more diverse, high-quality content. It started to grow participants on multiple sides, as well as create indirect network effects. For content providers, the move offered possibilities for generating complementarities in new environments that would attract players. The strategy also produced negative indirect effects in that multihoming constantly increased the platform complexity and decreased the entrepreneurs' control at the network and device layers.

The third move in this category was *Bypass.* It improved the quality and control of the service in two ways: by relying on a unique network and device layer solution that replaced solutions controlled by third parties. The move increased indirect network effects when one binding in the stack that had been controlled by an outside party was replaced by one controlled by G-cluster. The move increased access and control on multiple sides of the platform. It was targeted to allow the entrepreneurs to increase G-cluster's leverage over indirect network effects by increasing the reliability of the service and the diversity of the content. Through *bypass* moves, the entrepreneurs gradually increased G-cluster's autonomy. Content providers also exercised strong control over the content through access restrictions. To reduce this control, entrepreneurs expanded G-cluster's service into game development and introduced novel game content that drew on the platform's unique technical features. The general manager (technical development) explained the importance of the unique content: 'Especially in games, players require originality or big impressions, new user experiences, and so on. We have acquired many games and very famous titles, but we realized that we must provide original content for our players'. Again, this move increased participation on the

content provider side but also increased players' interest and indirect network effects due to the diversity and increased quality of the content.

Moves focused on *modifying binding properties* include *facilitate* and *constrict*. These moves modify boundary resources by changing how bindings on the platform stack can be configured. The *facilitate* move increased the diversity, quality, and quantity of the content by easing game developers' access to the platform. At this stage, the entrepreneurs shifted their focus to moves targeting the content/service layers. Not surprisingly, when the platform attracted more players, the need for high-quality and diverse content became more urgent. To address this need, the entrepreneurs improved the platform's capability to acquire, integrate, and deliver content by introducing SDKs. The vice president (software engineering) stated, 'We have had SDK in our internal use for years, but we have offered it to game developers since 2010'. Using these tools, game developers more easily produced and monetised content. The move also increased the indirect network effects by reducing the cost of participation and increasing its relative value. However, the growing diversity of the content might limit incentives to innovate for complementary devices if new and more diverse content engenders compatibility issues.

The *constrict* move aims to increase indirect network effects indirectly by standardising services, interfaces, and bindings that simplify and generalise the platform stack. In the long term, this move helps attract valuable content providers and increase the speed of integrating new services on the platform. *Constricting* can improve the platform's reliability, scalability, and cost of maintenance. At G-cluster, the move emerged after the *multihoming* or *bypass* move. The moves had increased the complexity of the platform and generated cumulative negative effects on the service costs and experience. To reduce governance costs and increase agility, the G-cluster entrepreneurs had to standardise critical sets of bindings by *constricting* them to a general, simplified solution. For example, the entrepreneurs constricted the network and device layers with arrangements that limited service operations to a set of reputable actors and large enough markets. The CEO explained: 'From 2005 to 2010 … we did a lot of work to get the platform to a more mature level. We developed it so that we are able to make large-scale installations that are scalable and more fault tolerant'. This move did not shape indirect effects directly, but gave options to do so in the future through improved agility, service quality, and the number of reputable content providers.

5. Discussion and conclusion

We identified six classes of competitive moves that entrepreneurs can use to increase indirect network effects. In line with this, we developed a dynamic model (Figure 4) that identifies moves and their sequences leading to growth in indirect network effects and consequently to a critical mass of users. Thus, this study expands previous literature (Armstrong 2006; Eisenmann, Parker, and Van Alstyne 2006; Rochet and Tirole 2003) that overlooked the critical role of entrepreneurial agency in creating indirect network effects (Evans and Schmalensee 2016). Thus far, some researchers have focused only on the general dynamics of growth in the overall participant network (Afuah 2013).

Our analysis suggests that when technologies and markets remain immature and uncertain, entrepreneurs cannot fully and accurately anticipate feasible services and organise their stack and related bindings leading to indirect network effects in one planned sequence. To overcome this difficulty and uncertainty, entrepreneurs engage in a series of trial-and-error searches – that is, effectuation (cf. Sarasvathy 2001, 2008) that can eventually produce multiple, potentially feasible bindings at the device and network layers. The process garners valuable feedback on how it is technically feasible to orchestrate the stack, how to manage it architecturally, and how to build internal competencies. That is, the growth process is path dependent, and the entrepreneur's previous choices and existing resources and capabilities impact how further bindings and services are formed. As we found, the firm's entrepreneurs' early moves centred on finding a feasible binding on the device and network layers that overcame technical challenges. However, when these critical

technical challenges were solved, the entrepreneurs' attention shifted, and their moves focused on solving strategic challenges that primarily targeted the service and content layers.

These findings extend previous research on mechanisms that promote growth on digital platforms endowed with direct network effects (Afuah 2013; Gawer 2009; Thomas, Autio, and Gann 2014; Trabucchi, Buganza, and Verganti 2021). For instance, previous research suggests that the quantity and density of user networks play an important role in social media platforms (Evans 2009; Evans and Schmalensee 2016). In contrast, our findings suggest that in multi-sided digital content platforms, entrepreneurs' capabilities to create versatile bindings between multiple device and network combinations, as well as navigate between several vertical and horizontal markets, played a decisive role in creating indirect effects. Furthermore, previous research suggests that videogame players represent a highly heterogeneous group of users with diverse preferences, tastes, and habits (Griffiths, Davies, and Chappell 2004). This heterogeneity increases the importance of promoting the diversity and quality of content (cf. Trabucchi, Buganza, and Verganti 2021), in addition to taking care of a sufficient number of providers. In this regard, moves addressing multihoming (for market penetration) and content acquisition (for improved market presence) are very important.

Overall, the study makes several important contributions to the nascent field of digital entrepreneurship and platforms (Nambisan 2017). This study is one of the first to examine the evolution of a digital platform longitudinally and illustrate how entrepreneurs build a viable platform from scratch and then initiate growth that creates cumulative indirect network effects. In previous studies, scholars have primarily investigated established platform firms like Google, Amazon, Facebook, etc., within relatively short time windows (Gawer and Cusumano 2008; Parker, Alstyne, and Choudary 2016) and explained retrospectively how indirect network effects emerged (Evans and Schmalensee 2016; Rochet and Tirole 2003). Most of these works focus on the number of participants as the main driver of indirect network effects (Afuah 2013; Karhu, Heiskala, and Ritala 2020). In contrast, this study offers a more nuanced analysis of how entrepreneurs create various value-creation mechanisms that can promote indirect network effects. Our analysis also reveals that these mechanisms are interrelated and emergent. They may also impinge a negative influence on indirect network effects. This analysis augments the dominant economic analyses of platform growth and change (Evans 2009) that focus mainly on demand and supply equilibria (Parker, Alstyne, and Choudary 2016).

We also contribute to notions of agency within digital entrepreneurship (Nambisan 2017) and its importance (Alvarez and Barney 2010; Nambisan 2017; Sarasvathy 2001, 2008) in shaping the platform stack and related services. In the context of multi-sided digital platforms, our use of layered modular architecture (Yoo, Henfridsson, and Lyytinen 2010) as a sensitising or framing device allowed us to identify a wide scope of moves available to digital entrepreneurs and how these moves and their sequences manifest entrepreneurs' strategic intent and related choices. This

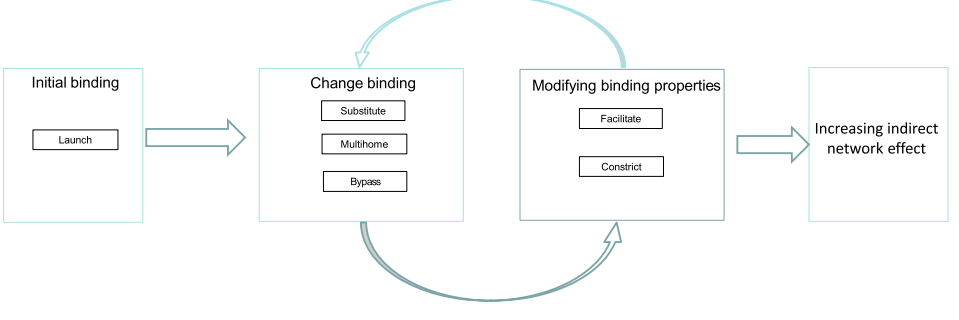

Figure 4. Process model for increasing indirect network effect.

analysis addresses Nambisan's (2017) recent call for studies of how digital platform features interact with entrepreneurial agency and open up entrepreneurial opportunities.

This study also has several limitations that call for future research. We conducted a longitudinal single-case study that allowed us to investigate the focal phenomenon in context. The method cautions against making too-strong generalisations. Instead, the findings offer a baseline for further research on the evolution of multi-sided platforms. The generalizability applies directly to most multi-sided content platforms – such as Netflix, Spotify, and Audible – where owners connect content providers and end users using a range of delivery devices and networks. With other platform categories, the theoretical story is likely to be different because the leverage is in transaction costs and because the impact of indirect effects and conditions is different (e.g. Airbnb; Karhu, Heiskala, and Ritala 2020; Parker, Alstyne, and Choudary 2016). Further studies on the dynamics of moves during platform competition will help advance novel digital entrepreneurship theories (Nambisan 2017), which improve the accuracy in explaining competitive behaviour and its outcomes. Finally, the data collection focused solely on corporate leadership, while the experiences of video game players or other stakeholders were excluded. Future studies would benefit by integrating the user- or competitor-side experience and considering how innovation and shifting preferences affect the platform evolution and influence the size of direct network effects.

Notes

1. The term 'bind' or 'binding' refers to different options for building the platform stack. Different bindings are based on interfaces between different layers of a multi-layered architecture.
2. This study covers the years 2000–2015 as there was a huge change in G-cluster's business model and operation logic in 2016. After G-cluster developed a successful working cloud gaming solution and proved its operability, the firm focused on (almost solely) developing cloud gaming technology and licensing it to large well-known brands in the gaming industry.
3. We cannot show use numbers because of confidentiality agreements. Note that all games are not available across all channels. Many games are country-specific (e.g., targeted to Japanese players) or have geographic limitations for supply purposes because of licensing arrangements.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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