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R&D MANAGEMENT

Complementors as connectors: managing open innovation around digital product platforms

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In the digital age, open innovation is increasingly organized around platform ecosystems. This paper investigates how firms can coordinate open innovation as a platform strategy for the development of complementary products by independent third parties. We draw on a qualitative case study of Philips Hue – a connected lighting platform for consumers with its variety of complementary products. We identify three increasingly complex ways in which independent complements connect to a focal platform. Our findings show that managing these connections requires a hybrid open innovation approach that combines arm's length coordination, with a large number of complementors through open interfaces, and intensive bilateral collaboration, with a selected number of partners. Our findings demonstrate that complex interconnections across digital platforms and products lead to the management challenge of navigating an 'ecology of platforms', which warrants future research.

1. Introduction

Organizations cannot achieve their innovation goals in isolation and need to engage in open innovation (e.g., Chesbrough, 2003; Enkel et al., 2009; Gassmann et al., 2010). Most open innovation research has investigated how organizations benefit from inbound and outbound *knowledge flows* to access the ideas or technologies needed for innovations (e.g., Dahlander and Gann, 2010; West and Bogers, 2014). Some of these open innovation activities concern the development of *complementary* products. These can involve intensive, coupled processes in bilateral partnerships (Gassmann and Enkel, 2004), like how the Philips Senseo coffee maker was designed in tandem with Sara Lee coffee pads (Deken and Lauche, 2014). With the advent of digital technologies, though, the development of complementary products by external parties is increasingly organized around digital product *platforms* that are managed through arm's length interactions with complementors (e.g., West, 2014; Bogers et al., 2017), like how third parties develop apps for smartphone operating systems.

Current literature on open innovation, however, offers insufficient insight in how 'open innovation as a platform strategy' (West, 2014, p. 90) can be effectively coordinated – although this form of open innovation is becoming more prevalent and features distinct managerial challenges for platform owners

(West and Bogers, 2017). Such a strategy enables the development of a large variety of complementary products, or complements, that increase the use value of platforms (Boudreau, 2010; Gawer, 2014). The digital technologies that underlie such platforms enable complements to connect in myriad ways with other products (Yoo et al., 2012; Henfridsson et al., 2018). Consider, for instance, how Spotify is integrated in other websites and offers connections to third-party products, such as speakers and ticket services. Because these connections may be created by independent third-party actors, platform owners cannot directly control these (Boudreau and Jeppesen, 2015). The sheer amount and variety of complements are challenging to coordinate through bilateral, intensive partnerships, but also arm's length coordination is likely insufficient when complements provide core value to platform users. Therefore, it is necessary to understand how the complexity of potential connections between digital products can be managed to deal with organizational and technical challenges. We pose the following research question: *How do platform owners manage open innovation to coordinate the development of diverse complementary products on their digital platform?*

Based on an in-depth field study of the Philips Hue smart lighting platform, and by drawing on literature on platform ecosystems (e.g., Baldwin and Woodard, 2009; Gawer, 2014), we found that independent app developers not only add new use cases but also create bridges across products by recombining platform interfaces. Furthermore, we find that a focal product platform may become embedded in broader platforms. For each of these three types of complements, we identify opportunities and risks and document ways a platform owner can address these.

The findings from our field study have multiple implications for managing open innovation with complementors. First, we show that firms operating in a digitizing world need to orient open innovation activities to increasingly complex connections between platforms and complementary products. We found that complementors act as 'connectors' by enabling three types of connections, which extend beyond the 'dedicated complements' mostly suggested in literature on platform ecosystems. Second, our findings show that these different types of connections call for a hybrid approach to coordinating open innovation around platforms. Collaboration around digital product platforms combines arm's length coordination through open and standardized interfaces (e.g., APIs) with more intensive partnerships that enable deeper integration between complements and platforms. Third, our findings indicate that connections created by independent third parties go beyond the full technical and organizational control of platform owners, because digital product platforms get increasingly interconnected in an 'ecology of platforms'. These interconnections pose new opportunities and risks that warrant future research.

2. Theoretical background

Open innovation has received much attention in technology and innovation management (Bogers et al., 2017). The key tenet of open innovation is that the involvement of external actors can spur an organization's innovation process and outcomes (Chesbrough, 2003). Open innovation scholars have focused on the inflow and outflow of knowledge as the predominant way to involve external partners (e.g., Chesbrough, 2003; Gassmann and Enkel, 2004; Laursen and Salter, 2006; Dahlander and Gann, 2010). By buying complementary knowledge from external partners (Cassiman and Valentini, 2016) or by sharing knowledge in formal collaboration structures such as R&D alliances, joint ventures, and project-based organizations (e.g., Faems et al., 2010; Hopkins et al., 2011), firms are able to develop superior innovations than based on their internal knowledge alone. In many of these open innovation cases where external actors provide input to the innovation process, the actual development of new products and services remains the domain of a focal firm.

In other cases, though, companies may couple inbound and outbound innovation activities in bilateral collaborations to develop and market *complementary* products and services (Gassmann and Enkel, 2004; Deken and Lauche, 2014; Piller and West, 2014). Consider, for instance, the collaboration between Apple and Nike to develop the Nike+ platform connecting Apple iPods to Nike running shoes (Ramaswamy, 2008). Such coupled processes typically involve intensive collaboration in alliances and other types of partnerships (Enkel et al., 2009; Piller and West, 2014).

With the advent of digital platforms, another form of open innovation for the development of complementary products is becoming more prevalent, which extends beyond bilateral collaborations: A firm may offer an open platform that allows external actors to participate in the development and commercialization of complementary products (Boudreau, 2010; Gawer and Cusumano, 2014; West and Bogers, 2017). Examples of platforms and associated complements include smartphones and apps (Ghazawneh and Henfridsson, 2013; Eaton et al., 2015), video game consoles and games (Schilling, 2002; Cennamo and Santalo, 2013),

and ERP platforms and implementation services (Wareham et al., 2014). Such complements can extend the platform's use and functionality and may come in the form of hardware, software, or content. Literature on platform ecosystems offers further understanding and points at challenges for 'open innovation as a platform strategy' (West, 2014).

The value of an open platform strategy lies in the variety of available complements and the recombination potential that these offer to users. Opening up platforms enables external actors to develop complementary innovations in areas that are outside platform owners' expertise (Von Hippel, 2005; Pruegl and Schreier, 2006) or economically unattractive to them (e.g., niche applications, Baldwin et al., 2006; Shah and Tripsas, 2007). In such way, platform owners and developers of complementary innovations can develop a highly symbiotic relationship (Baldwin and Von Hippel, 2011) based on a division of labor where the platform owner defines and develops core platform components and facilitates the development of complements to expand the platform's 'reach and range' (Nambisan and Sawhney, 2011). Taken together, the generative advantages of digital product platforms can build momentum behind a technology, eventually paving the way to becoming a leading platform (Gawer and Cusumano, 2014).

However, this dynamic nature of digital platforms does not come without challenges. As digital technologies allow for myriad connections with other products and services that continue to evolve (Yoo et al., 2012; Henfridsson et al., 2018), the increasing complexity of those connections makes it more difficult for firms to control and manage their platforms, requiring coordination at *technical* and *organizational* levels.

Research on digital product platforms and modularity offers extensive explanations for how the connections between platform and complements can be managed on a *technical* level. Digital product platforms consist of different loosely coupled modular layers (Baldwin and Clark, 2000; Yoo et al., 2010), which reduce the dependencies between the core platform and its complements. Specified interfaces, like 'application programming interfaces' (APIs), form the 'glue' between different modules. Platform owners may provide specifically designed toolkits (Ghazawneh and Henfridsson, 2013) – including API documentation and 'software development kits' (SDKs) – which help external actors to produce complementary innovations that connect to the platform and thus can be shared with others (Pruegl and Schreier, 2006; Boudreau and Jeppesen, 2015; Eaton et al., 2015).

Opening a digital product platform poses additional challenges on an *organizational level*. For example, platform owners and complementors need to navigate complex strategic landscapes involving competition and collaboration (Gawer and Cusumano, 2014), and ensure that the value of the platform is not diminished for developers and users by becoming too varied and fragmented (West and Gallagher, 2006). Extant research on digital platforms suggests that standardized interfaces can facilitate coordination between the platform owner and complementors also on an *organizational* level, because conformance to a standardized API allows third parties to innovate autonomously without explicit coordination between the platform owner and complementors (Ghazawneh and Henfridsson, 2013). However, this is precisely what drives the rapid evolution of a digital platform by highly distributed parties (Tiwana, 2013), which makes the evolution of a platform and its complementary products so unpredictable and difficult to manage (Garud et al., 2008; Yoo et al., 2012).

Because current literature provides insufficient insight in how firms can address such challenges of open innovation for the development of complements for digital platforms, it is important to investigate how platform owners can successfully manage the relationships with heterogeneous external actors to harness the benefits of open innovation as a platform strategy, while minimizing the potential risks. This leads us to empirically investigate how platform owners coordinate the development of complements aimed at increasing the value of the platform, such that technical and organizational interdependence does not risk the integrity of the overall platform.

3. Method

3.1. Research setting

We performed an in-depth case study (Eisenhardt, 1989) of the Philips Hue smart lighting system (hereafter, shortly 'Hue'). Since its launch in 2012, Hue has generated much traction and became the most prominent consumer platform for smart lighting. To advance insight on open innovation through digital platforms, we studied connections within the larger ecosystem around Hue (i.e., between the Hue platform and other products and platforms). By studying these connections as embedded cases (Yin, 2013), we identified how Philips[1] coordinated different types of complementors on its platform to realize open innovation.

Hue is a particularly suitable research setting for the following reasons. First, the Hue system is an excellent example of a digital product platform: Philips transformed its traditional lighting products by adding intelligence and connectivity and developing a platform for soliciting contributions from complementors such as third-party developers (e.g., Yoo et al., 2012). Second, smart lighting is particularly suited to study how platforms get connected: smart lighting is part of the larger home automation ecosystem, for which interoperability with other products (e.g., smart locks, audio) is a key issue (Peine, 2008). Third, Hue is a very successful platform, as it has attracted more than 400 third-party apps and is considered a preferred partner for many other large home automation players (e.g., Apple, Google, Amazon).

3.2. Data collection and analysis

We collected a variety of qualitative data to gain insight into the technical and organizational aspects involved in the connections between the Hue platform and complements and the associated relations between Philips and external actors (see Table 1 for an overview of the data sources). We performed formal interviews with 15 Hue team members. In addition, the first author engaged directly with the Hue team during weekly field visits (Van de Ven, 2007) between November 2015 and December 2016. Informal conversations with the Hue team and meeting observations were documented in field notes.

We collected data on all apps and other complementary products for Hue. We selected specific apps that connect with Hue as *embedded cases* (Yin, 2013) for in-depth investigation. For these cases, we collected additional secondary data (e.g., press releases, tech blogs) and interviewed 22 third-party developers about their apps and development process.

We analyzed the collected materials using inductive coding procedures (Miles and Huberman, 1994) to understand how connections had been established between the Hue platform and complementary products. Table 1 shows how we used the different data sources to triangulate our analysis. For each of the selected embedded cases, we analyzed the technical integration with Hue and other platforms, their coordination and interaction with Philips, and the consequences for Philips as platform owner. Through a cross-case analysis, we developed an explanation on how different types of increasingly complex connections were associated with the relationships that developed between Philips and the various independent external actors who developed complements. The first author discussed emerging insights with the Hue team to check the internal validity of our findings.

4. Findings

4.1. Introducing the Philips Hue platform

The core products in the Philips Hue platform are LED light bulbs with connectivity capabilities. Philips has also launched lightstrips, light switches, and a sensor. In order to operate these devices, users need the 'Hue bridge' – a hub connected to a local WiFi network – that communicates with the network of devices, for example to change light color or intensity.

Users can send commands to the bridge via an official iOS and Android smartphone app. This app, for example, allows creating and selecting 'scenes' (i.e., combinations of colors for different light bulbs to create a particular atmosphere) and 'routines' to set timers to automate the lights.

Between 2012 and 2017, external developers have launched over 400 complementary third-party apps that connect to the Hue bridge through an open API. Through these apps, complementors have increasingly integrated Hue with a range of diverse products. Moreover, the Hue platform has become embedded in several home automation platforms (e.g., Samsung SmartThings, Amazon Echo, and Apple HomeKit).

From our analysis of complements to the Hue platform, we have identified different ways in which complementors have made Hue interoperable with other products and platforms. We distinguish three types of connections that connect complementary products in increasingly complex ways to the Hue platform: (1) dedicated complements that connect to Hue only; (2) complements that bridge the Hue platform and other products; and (3) embedding Hue in broader platforms that connect to an open-ended set of products and services. Next, we discuss an exemplary case per type to unravel how technical and organizational connections are established and reflect on how Philips managed these connections. Table 2 provides an overview of these three types and an additional case per type.

4.2. Dedicated complements

A large share of complementary products for Hue involves a single integration with the Hue platform through *dedicated complements*. That is, third-party apps interface specifically with Hue and offer additional value *exclusively* to Hue. Independent

Table 1. Overview of data sources

Data source	Details	Use of data
Observations	Observations at Philips Hue headquarters, on average one day a week, from November 2015 to December 2016 Informal conversations with Philips Hue team members from different departments Attending (biweekly) meetings of Philips Hue partnership team	These observations and informal interactions with the core Hue team provided a us with a solid understanding of the day-to-day context. These data helped to make sense of how and why particular technical and organizational choices were made (providing a glimpse 'behind the scene' that put decisions and events in perspective). Alongside early data collection and analysis, we asked clarification questions when these emerged, and at later stages we validated our emerging findings, thereby triangulating our findings and safeguarding the internal validity
Formal semi-structured interviews	Fifteen formal interviews with Philips Hue team members (including: product owners, system architects, head of technology, former and current developer support and 'developer evangelist', director standardization, director partnerships, senior scientists/researcher, and designers)	These interviews helped to understand the broader development trajectory of Hue and provided deeper insight in the considerations and reflections of interviewees on past events and future plans, specifically regarding collaborations with various external parties. Moreover, the interviews shed light on the considerations regarding the official Hue partner program and the developer program
	Twenty-two semi-structured interviews with third-party app developers (through Skype)	In the interviews with third-party developers, we learned about the story behind the apps (e.g., the app's use case, what resources developers used, and for what reason). Moreover, these interviews shed light on how the actions of the Hue team were experienced by developers and how the resources provided by Philips were used (or not) by developers
Philips company communication	• Press releases from Philips regarding the Hue platform published between 2012 and 2016 • Publications published on the Hue consumer website (meethue.com) (e.g., FAQ, release notes) • Developer portal (developers.meethue.com) communication on the forum and documentation about the API • Social media messages (e.g., Twitter) • Public presentations (YouTube) and guest lectures by Hue team members	We used these external communication documents by Philips as sources to identify key developments in the Hue platform and the increasing connections to complementary products and platforms. From these data, we discerned different strategies for addressing different complementors (e.g., independent developers versus formal partners). The developer portal gave insight in the technical resources provided by Philips such as the API, providing insight in how Philips managed these connections
Press releases	News items and statements published by other platforms that interoperate with Hue (e.g., by Apple, IFTTT)	Similar to Philips' external communication, press releases by complementary platforms gave insight in key events and background of the integration
App data	Data from app stores and AppAnnie about apps that connect with Hue	An overview of all available apps with Hue integration was used to analyze different types of connections. App data was then used to select embedded cases and sample third-party developers for interviews
Tech blogs	Articles and commentaries published by e.g., ProgrammableWeb, FastCompany, clnet, Engadget, Mashable, and TechCrunch	Particular decisions with regard to the Hue platform raised both positive and negative responses by technology enthusiasts, who voiced their opinions on tech blogs. These articles and posts gave an additional perspective of enthusiastic users and independent developers into the consequences of developments in the evolving Hue ecosystem

Table 2. Analysis of embedded cases

	Dedicated complements that connect to a focal platform only		**Bridging complements** that connect to a focal platform as well as to other products or platforms		**Embedding the focal platform** within a broader platform with an open-ended set of connections to other products	
Illustrative case	*MusicHue*	*Sunset-for-Hue*	*AutoMate*	*LightHouse*	*IFTTT*	*Apple HomeKit*
Use case	App that synchronizes light colors and intensity with the rhythms and beat of music	App that automatically adjusts the timers of Hue lights to actual sunrise and sunset times	App that integrates beacons (devices that transmit location-specific information) with Hue to enable light control through advanced location recognition	App that offers sophisticated light control for *all* types of light bulbs (including lamps from competing digital product platforms)	IFTTT (If This Then That) is a platform for connecting various IoT services and enables users to create and share 'recipes' that combine triggers and actions	Apple's way into home automation; allows users to control their home automation devices through one integral 'Apple Home' app
Technical integration	**Adopting the API:** connecting to the open API (local Hue API)		**Recombining APIs:** connecting to multiple open APIs and/or other frameworks (including the Hue open API)		**Customized integration:** connecting to closed API and/or other partner-specific frameworks (e.g., Hue remote API, a new certified chip and firmware in the Hue bridge 2.0)	
Organizational integration	**Arm's length.** Autonomous developer activity (mostly user innovators and independent app developers) and interactions through third-party developer program		**Arm's length and potentially some direct contact.** Mostly autonomous developer activity (including user innovators, independent professionals, small app development agencies, and other home automation firms), and interactions through third-party developer program and some informal personal contact with the Hue team		**Partnerships**: Specific partnership agreements and close collaboration for each integration with partner organizations, supported through the partnership program 'Friends of Hue' and through direct interactions with other platform owners)	
Opportunities (+) and risks (-) for platform owners	+ Increased overall value of the Hue platform by new use cases – Increased competition between official Hue app and other third-party apps – Less control over user experience – Losing (part of) the user interface		+ Increased overall value of the Hue platform by integrating with other products and platforms – Limited control over what integrations are made by third-party developers that may jeopardize the overall system integrity – Integrations with competing product platforms		+ Increased overall value of the Hue platform by becoming integral part of larger ecosystem + Combine user bases + Co-branding + Ensure quality of integration – High coordination costs – Being (partially) enveloped in the broader platform	
Managing risks and opportunities by platform owner	Support developers ('Hue Developer program') Provide a well-documented, open API Showcase apps ('More apps for Hue') Regulate use of branding (Hue terms & conditions) Encourage developers to ensure integrity of their app over time Balance features in own app and in complements		Extend API functionalities to enable integration with additional products and platforms Restrict access of competitor products		Manage agreements and integration with other platforms (Philips Hue partnership program 'Friends of Hue') Seek partners for new integration to grow the user base Joint marketing Provide standalone value through own complements (official Hue app)	

developers, often inspired by their own user needs, add value to the Hue platform by providing new or extended functionalities. Next, we briefly discuss the MusicHue case to illustrate how complementors create connections with Hue through dedicated complements.

MusicHue[2] is a highly popular app that syncs light color and intensity with the beat of a song. At the time of development, the official documentation about the Hue API had not yet been published by Philips. Through '*sniffing*' the system, the developer reverse-engineered the commands needed to interface with the Hue lights and designed one of the first third-party apps for Hue.

The popularity of MusicHue helped generating a buzz around Hue, which attracted new users and developers to the platform. As more users adopted Hue products, developers increasingly started to develop complementary products. When Philips launched an official developer program, this trend was further reinforced resulting in fierce competition among developers. The MusicHue developer, however, managed to outperform competition by offering a high-quality app that is frequently updated.

4.2.1. Managing dedicated complements

MusicHue illustrates how dedicated complements add value to the Hue platform by implementing additional features that extend user functionality. Third-party developers build dedicated apps around specific new use cases. The *technical integration* happens through the local API that such apps comply with to connect to Hue. The *organizational integration* happens at arm's length and is facilitated by Philips' developer program, which provides independent developers access to API documentation and support on how to integrate with the system.

Dedicated complements offer additional value for users and platform owners alike. However, there are also risks involved. While extended functionality offered by third-party apps is valuable for users, platform owners may be concerned if superior functionality is crowding out their own app. Because developers compete with the official Hue app, they try to introduce distinctive features. Users may begin operating their Hue lights exclusively through third-party apps, which implies that Philips may lose control over the user experience. This lack of control may become problematic for platform owners if the quality of complements deteriorates over time and the poor user experience reflects badly on the platform. In the Hue case, an increasing number of developers invested their efforts in developing new apps rather than maintaining already existing ones, jeopardizing the integrity of the apps and potentially the entire Hue platform.

Platform owners can manage the opportunities and risks associated with dedicated complements through organizing a developer community. In October 2016, more than 30K members were registered for the Hue developer program, of which a minority had (yet) developed an app. The Hue team offers support through a developer forum and, in some cases, through direct interactions with third-party developers. The developer program is a vehicle for Philips to avoid interoperability problems by nudging complementors to comply with the official API.

Furthermore, Philips tries to regulate the use of its brand. The terms and conditions of the developer program clearly state that developers may not claim any affiliation between Philips and themselves or their app: '*Make sure it is very clear from all you do that your app belongs to you and not to Philips Lighting. You take sole responsibility for your app. Do not use any Hue or Philips Lighting branding trademarks […] or Philips Lighting in any logo or graphics*'. By urging developers not to use Hue branding, Philips signals to users that the apps do not fall under their remit, so that they cannot be held accountable for poor quality apps.

What complicates matters is that Philips is constrained in their control because they depend on overarching platforms like the Apple AppStore for vetting apps. Philips does however promote '*Apps we like*' in their own Hue app, so that end users are made aware of the available complementary apps, thereby helping loyal and high-performing complementors to attract downloads. Through the developer program, the Hue team reminds developers to maintain their app and remove nonfunctioning apps from the AppStore.

Finally, platform owners may use dedicated complements as a source of inspiration to extend platform functionality. However, adopting features of third-party apps in a way that cannibalizes those apps is a delicate issue, because this may decrease complementors' motivation to remain active on the platform. Indeed, when Philips adopted voice control in their official app, a developer that already offered that functionality in his app decided to stop developing for Hue. This shows that platform owners need to carefully consider which features to adopt from complements in order to avoid dynamics that can be detrimental for the platform.

4.3. Complements that bridge products

Other cases demonstrate how third-party developers have connected the Hue platform to other products

by integrating with *other external open APIs*, resulting in 'bridges' that Philips had not foreseen nor intended to design. The following case shows how developers can bridge products by creatively and skillfully combining APIs in their apps.

4.3.1. LightHouse

The idea for this app was born when the developer received the Hue lights as a gift. When he '*hooked up*' the Hue lights, he had '*the aha-moment*', realizing that '*light is something that matters!*' He was, however, unhappy with the official Hue app: '*I wanted a little more control—with a certain level of sophistication*'. Using his coding skills, he created the LightHouse app, which allows users to configure lights precisely by color code. This feature turned out to be particularly useful for small theaters, so that producers are '*able to have light cues where they can put in exactly what they want*', without having to buy '*fancy*' stage lights.

Besides Hue lights, this app also supports lights and switches from competing manufacturers. The main reasons for combining systems was that the developer felt that the Hue product range missed certain products (e.g., smart plugs) and is the most expensive connected lighting system for consumers. Since manufacturers of competing light bulbs also provide an open interface, the developer could integrate these different products into one app and target a larger user base.

4.3.2. Managing complements that bridge

The LightHouse case illustrates that complementors may envision integrations that go well beyond what platform owners could have foreseen. Third-party developers create value for a focal platform and its users by extending the range of products to connect with. On a technical level, these complements that bridge products are realized by combining various open APIs. The organizational integration happens mostly at arm's length as complementors independently develop their apps. Our analysis shows that bridging different complements offers greater value for users and platform owners than is typically the case for dedicated apps merely adding a feature.

However, platform owners have limited control over what integrations are made by third-party complementors. In our example, complementors connected the Hue platform with competitor products. Some developers were even approached by Philips' competitors who offered free smart bulbs for potential integration in their app. While this is beneficial for third-party developers and users, it may be undesirable for platform owners who may sell fewer of their own products. A second challenge associated with these kinds of complements is that the dependence on other APIs – over which platform owners have no control – can jeopardize the overall platform integrity. In the LightHouse case, the same user command resulted in 'bright green' Hue lights, while other lights turned 'warm yellow', and users blamed the app for '*not doing green right*'. When third-party developers encounter such hardware-related incompatibilities across platforms, they often cannot easily resolve such problems. For platform owners and complementors, this may result in complicated situations where they are hold accountable for issues beyond their control.

Platform owners can address the challenges and risks associated with complements that bridge across products by updating the system to add previously unsupported scenarios. Moreover, platform owners can restrict their system to prevent competitor products from connecting to their platform. In the update of December 2015, Philips banned competitor light bulbs to avoid '*interoperability issues resulting from untested third-party products*'. Yet, after a customer outcry on forums and online stores, Philips reversed their decision within a week. This example shows that once complementors have established connections, platform owners may have great difficulty to change these for their benefit but rather have to deal with the consequences for better or worse.

4.4. Embedding in platforms

The Hue platform has also become *embedded* in broader platforms, which resulted in new and open-ended connections to other products and services. While the first two types of connections added functionality and loosely coupled other products to Hue, this third type is different as it makes Hue a tightly integrated part of broader platforms such as smart home platforms. Next, the Apple HomeKit case shows that these complex connections involve adaption of the focal platform and that collaborations need to go beyond arm's length interactions between the involved platform owners.

4.4.1. Apple HomeKit

Philips was one of the launching partners of Apple HomeKit when it was announced in June 2014. HomeKit is a framework that allows users to connect smart home products and to manage their home through a single-user interface rather than using distinct apps per product. In Apple's press release, the CEO of Philips Lighting, stated: '*We are excited to be part of the next step in making home automation a reality, in a safe and integrated way [...] HomeKit will allow us to further enhance the Philips Hue lighting experience by making it simpler to securely*

pair devices throughout the house and control them using Siri'.

However, implementing this connection was far from straightforward. It took until October 2015 before users could actually benefit from the HomeKit integration: Philips had to first develop and release new hardware with an Apple certified chip. In addition to buying and installing this new Hue bridge, users had to update their Hue app to enable Siri functionality. The HomeKit integration also involved launching a HomeKit API, which allowed third-party developers to use the HomeKit framweork rather than the Hue API. This enabled third-party developers to use a single interface to address all HomeKit certified products on the market.

4.4.2. Managing embedding in platforms

Next to inviting third-party developers to develop complements for Hue, Philips has also joined broader smart home platforms, which aim to deliver an integrated user experience across a variety of products and services. Such integrations with broader platforms cause Philips Hue to indirectly interoperate with products and services associated with these platforms, making these platforms mutually complementary. Through establishing these indirect connections between Hue and a plethora of complements, becoming embedded in another platform has far-reaching and unprecedented effects.

The technical integrations required to embed a focal platform in another one goes beyond what can be accomplished with an open API and may require the platforms to mutually adjust and bring in additional platform resources. On an organizational level, such connections require close collaboration through formal partnerships of platform owners. To integrate with the IFTTT platform (see Table 2), Philips had to adjust their open API to enable remote access – a feature that until then was only available for the official Hue app. In close collaboration, development teams of Philips and IFTTT coordinated the changes that were necessary, such that integrity of both platforms was maintained and breakdowns would be prevented.

Embedding in other platforms creates value for users as it provides them with an increased variety of choice to combine their Hue lights with other home automation and IoT applications. Platform owners may benefit from tapping into additional user bases. The publicity that followed Philips Hue's announcement to integrate with these platforms underscores the potential value of associating with other platforms. Furthermore, the quality of integration is under the direct control of platform owners. However, the HomeKit example also showed the high coordination costs that may be required for such an integration. Because new hard- and software had to be introduced to realize the connection between Hue and HomeKit, these integrations involved a collaborative effort of the platform owners. In particular hardware changes complicated the integration as these require more time to develop and incur additional costs for users who have to purchase new hardware. Furthermore, through embedding, a focal platform risks becoming (partially) enveloped, i.e., that the functionality and user base gets absorbed by the broader platform.

To manage the challenges and opportunities of embedding, the Hue team started a partnership program which became formalized in the 'Friends of Hue' program. As part of this program, the Hue team actively sought new integration partners to tap additional user bases. A key element of their strategy was to identify platforms that justify the additional effort required for a partnership compared to the arm's length interaction with typical complementors. This approach reflects the important insight that platform owners need to weigh these higher coordination costs against the benefits of getting access to an additional user base. In addition, Philips made an effort to maximize the potential of additional user bases through joint marketing. For example, the Friends of Hue program involves elements of co-branding, such as the creation of a Friends of Hue logo that other platforms can use in their marketing.

Finally, to prevent the risk of becoming fully enveloped by a broader platform, companies like Philips need to ensure that their platform and own complements provide some stand-alone value that cannot be replaced by these broader platforms. Another defensive strategy used by Philips was to make sure they do not partner with a single dominant platform only; rather they integrated with both Amazon Echo as well as Google Home and Apple HomeKit to avoid becoming overly dependent on any of these platforms.

5. Discussion

By investigating coordination in the development of complementary products for digital product platforms, our study extends our understanding of coupled open innovation for the development of complementary products (Gassmann and Enkel, 2004). We add to the emerging stream of literature on open innovation as platform strategy (West, 2014) by elaborating the concept of 'complements' from the literature on platform ecosystems. The Philips Hue data show how a platform owner needs to manage diverse and evolving connections with complementary products that may span across multiple

platforms that introduce new opportunities as well as risks for platform owners to address in the development of complementary products by external parties. We now further specify the implications of our findings for open innovation.

First, our findings show that external actors develop increasingly complex connections to a platform. We distinguish three types: (1) dedicated complements connecting to a focal platform only; (2) complements that bridge a focal platform and other products; and (3) embedding the focal platform in a broader platform with an open-ended set of connections to other products and services. These latter two types of connections extend the open innovation literature that has primarily been concerned with dedicated bilateral connections between products (as the coffee maker and complementary coffee pads) and dedicated complements for platforms (e.g., Boudreau and Jeppesen, 2015).

Furthermore, the Hue case demonstrates that these increasingly complex connections with complements extend beyond what was intended and foreseen by focal platform owners. Thus, the generativity resulting from third-party innovations not only yields a variety of complementary products that address heterogeneous user needs (see also Von Hippel, 2005; Pruegl and Schreier, 2006), but also new recombinations and integrations beyond the original platform. Enabled by increasingly open APIs, complementors in the Hue case strived to develop new use cases, for which they rarely addressed one platform only; rather, their innovations created connections across multiple platforms. This insight extends our understanding of how open innovation enables the development of complementary products and is important because it means that the value generated for customers may further increase, but also evades control by the platform owner.

Second, while much prior research on open innovation has focused on partnerships as an approach for the co-development of complementary products (typically in a coupled open innovation approach, Gassmann and Enkel, 2004), we show how open innovation on digital product platforms may require a hybrid open innovation approach – combining a large number of complementors at arm's length and intensive partnerships with a few selected complementors. On the one hand, our findings illustrate that APIs and open standards, besides being *technical* interfaces, facilitate *organizing* innovation with many heterogeneous actors (e.g., Ghazawneh and Henfridsson, 2013; Tiwana, 2013; Eaton et al., 2015). In contrast to interactive inbound and outbound open innovation (Gassmann and Enkel, 2004) associated with partnerships such as alliances and consortia (e.g., Faems et al., 2010; Hopkins et al., 2011; Deken and Lauche, 2014), open standards enable arm's length coordination between a platform owner and many complementors. These complementors include user innovators and independent professionals but also app development agencies and home automation firms. The open API model with loosely coupled relationships between complementors and platform owners suffices for dedicated complements and most complements that bridge across products.

On the other hand, when deeper integration is critical to achieve system integrity and a coherent user experience, the more costly coordination of coupled open innovation in a bilateral partnership model is justified. Specifically, for realizing strategic objectives that require two-way commitment, such as co-branding, the partnership model allows close interorganizational collaboration and tight technical integration going beyond what is possible through autonomous development. Yet, such open innovation partnerships are only feasible with a selected number of collaboration partners, for complex connections like embedding the platform in broader platforms.

These coordination mechanisms are not mutually exclusive but can actually reinforce each other. For example, an open API allows potential partners to experiment with the system before engaging in formal collaborations, which may facilitate initiating formal partnerships. Although the Hue case illustrates the potential of such a hybrid approach of combining both coordination mechanisms, it also implies that platform owners have to make strategic decisions regarding who to partner with and in which way. This calls for adopting a portfolio approach to managing open innovation (e.g., Faems et al., 2005) rather than seeking a balanced approach that applies to all connections (see Wareham et al., 2014).

Third, our findings have implications for our understanding of digital platform ecosystems and how they can be seen as open innovation ecosystems (Rohrbeck et al., 2009). Independent complementors can increasingly embed a digital product platform into a complex web of interdependencies between various digital products and platforms. Our study finds that connections created by complementors can span multiple platforms, leading to an *ecology of platforms*. These dynamics have not been sufficiently studied in the literature because, to date, platform ecosystem scholars have only studied complements specific to a single platform (e.g., Boudreau, 2010; Eaton et al., 2015). Some scholars have hinted that platforms do not exist in a vacuum. For example, platforms may be 'nested' when they simultaneously are complements in another platform (Tiwana, 2013) or exist 'on top of or embedded within other platforms'

(Gawer and Cusumano, 2014). Thus, our findings suggest the importance of studying an *ecology of platforms* rather than a single platform ecosystem.

Because independent complementors increasingly affect what users can do with the system by making connections to external platforms, the task for platform owners to safeguard the user experience (Rowland et al., 2015) and overall system integrity gets more difficult. Therefore, platform owners should recognize that complementors are nested in multiple platform ecosystems, which requires a different approach of managing access to and control of their platform (Ghazawneh and Henfridsson, 2013). Complements that bridge across platforms are particularly challenging to manage because the developer relationships are at arm's length while the connections created may have strong strategic implications. Recall, in the Hue case, how independent complementors integrated competitors' light bulbs in the platform that could cannibalize sales of own bulbs and introduced hardware issues that affected the overall system integrity.

As a consequence of the increasing number of connections realized by complementors, our findings suggest that such interdependencies may constrain innovation opportunities for digital platform owners over time. When every update of a digital product platform can have far reaching consequences for the stability and quality of the user experience – possibly jeopardizing the integrity of the entire system – platforms become path dependent and less attractive for generating innovations. Moreover, as Philips' inability to ban competitor light bulbs from its platform illustrates, it becomes difficult to abandon connections to other digital product platforms once they have been established.

Future research is needed to investigate how open innovation activities can be used to manage the relationships with various complementors in different digitizing industries. As we focused on a consumer platform, more work is needed to understand whether the challenges and solutions we discuss are applicable for digital business-to-business platforms. Further research is also warranted to better understand the different types of complementors and to what extent they can be managed differently. For example, while some complementors are established firms, others may be user innovators or entrepreneurs (Baldwin et al., 2006; Gassmann et al., 2010) who are driven by different motivations and thus need to be coordinated differently. A promising avenue might be to build upon research on the challenges of managing a portfolio of collaborators in open innovation (e.g., Faems et al., 2005). Such studies could further investigate and test the conditions under which different types of complementors should collaborate through partnerships or engage in arm's length collaborations through standardized interfaces. Additionally, this calls for further research on the role of knowledge flows for open innovation as a platform strategy. For example, what instruments can platform owners use to facilitate an adequate level of open knowledge flows for partnerships and arm's length collaborations. Furthermore, our findings underscore the need for open innovation research to examine multiple (embedded) levels of analysis (West and Bogers, 2017) and study 'ecologies of platforms' rather than single platforms to better reflect the increasingly connected nature of today's digital economy.

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Notes

1. In 2016, Philips spun off its lighting business. In 2018, Philips Lighting was renamed to Signify. The product name 'Philips Hue' has remained the same. In this paper, we refer to Philips (Lighting) because this was the company name at the time of the described events.
2. We use pseudonyms for the app and developer's names.

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