CHAPTER 1

Introduction

While innovating with today's emerging digital technologies offers all kinds of new and exciting opportunities for product development, it also implies that organizations need to reconsider how they organize their innovation processes. Digital innovation involves different hardware and software components, and value is created when such components become connected, generating new options for usage. From an organizational perspective, this means that in the 'digital age', organizations become dependent on other actors in their environment to develop, launch and maintain digitized products and services successfully. In this dissertation, I set out to study the challenges associated with managing digital innovation in ecosystems of heterogeneous partners over time. This chapter introduces the key theoretical concepts, the research approach, the outline of the chapters that comprise this thesis, and an overview of the output that resulted from this PhD project.

1.1 Organizing digital innovation

Digital innovation, defined as "the carrying out of new combinations of digital and physical components to produce novel products" (Yoo et al., 2010, p. 725), brings about almost endless opportunities for new product and service innovation. For example, in the 'smart home', we can equip our houses with connected light bulbs, robot vacuum cleaners, thermostats and door locks which can be controlled from anywhere with a smart phone (or even with your voice through virtual home assistants). Also referred to as the 'Internet of Things' (or shortly IoT) (e.g., Ng & Wakenshaw, 2017), some of these intelligent products and services are still mere fun gadgets for technology enthusiasts. However, increasingly digital technologies are employed for solving larger societal issues, for example in smart city solutions or home healthcare. One way or the other, intelligent products and services enter our daily lives—today or in the near future.

The creation of digital innovation is an exciting journey as well. While we know quite much about the organization of 'traditional' innovation activities, the nature of digital innovation brings about new dynamics to the development process. Digital innovation differs in that it is characterized by multiple "modular layers" (Yoo et al., 2010) of hardware and software, network capabilities for connectivity, and interfaces that form the 'glue' between the modules. Different organizations are responsible for contributing the components in these different modular layers. For example, in the case of smart phones, Google provides the operating system Android, device manufacturers like Samsung release supporting hardware, network operators are responsible for 4G connection, and third-party app developers build on open interfaces to produce the contents and services that make the smart phone worthwhile to use. To complicate matters, these organizations are heterogeneous: they vary considerably in size and type of industry, are highly distributed, and typically work autonomous.

As a result, *digital innovation management*, i.e. "the practices, processes, and principles that underlie the effective orchestration of digital innovation" (Nambisan et al., 2017, p.224) is complex and challenging. In particular managing the *technical* as well as *organizational* interdependencies demands careful coordination in order to have all components in the system work smoothly together. For incumbent and more traditional product-focused firms, who are accustomed to develop standalone products, this requires rethinking their innovation routines. For example, electronics company Philips[1] traditionally invested heavily in (fundamental) technological research as source for new product development, but, as the CTO, Henk van Houten, acknowledged: *"Innovation in the digitized world is substantively different. It is no longer about delivering the best MR-scanner, but instead about equipment that fits perfectly in the full system."* (Technische Weekblad, September 2014). Today, research at Philips has shifted to focus more on understanding societal developments and responding to these needs with innovative integrated product–service solutions. At the same time, to develop such 'total' solutions Philips increasingly relies on collaborative arrangements with a broader range of partners.

The implications of innovating with digital technologies have not gone unnoticed in academia; in particular at the intersection between technology & innovation management, information systems research, and organization science there is increasing attention for better understanding the organizational dynamics that digital innovation brings about. The growing interest is also reflected in the special issues on this topic that have been published and announced recently in a variety of (top) journals in the different fields of research (e.g., Organization Science published a special issue themed "Organizing for innovation in the digitized world" in 2012, MIS Quarterly on "IT and innovation" in 2017, and Research Policy announced a special issue on the "Digitalization of innovation and entrepreneurship"). Thus, as Nambisan et al. (2017) stated recently, "the time for new theorizing about digital innovation is, therefore, *now*" (p. 224).

In this dissertation I focus on organizing digital innovation processes in

1 To date, Philips is split in two companies: Philips Lighting and Philips HealthTech. In 2018, Philips Lighting changed its name into Signify. In this thesis I still use 'Philips Lighting' because this was the company name during the time of data collection and analysis.

ecosystems, paying special attention to the technical architecture (i.e., the plurality of physical and digital components in the different layers that compromise a digital innovation) as well as organizational aspects (i.e., the associated diversity of actors involved in the development of these components) of digital innovation. The overall research question is framed as follows: *How do organizations address the challenges of managing digital innovation in evolving ecosystems consisting of heterogeneous actors?* To answer this research question I address organizational challenges specific for three phases of ecosystem maturity: creation, growth and maintenance. Furthermore, in my studies, I take a *process perspective*, meaning that I consider the role of temporality in my theorizing, by paying special attention to how processes evolve over time (e.g., Langley et al., 2013).

In each chapter of this thesis I address a specific research question associated with different stages of ecosystem evolution. Together the findings from each chapter contribute to an advanced theoretical and practical understanding of organizing digital innovation in ecosystems. In the following sections of this introductory chapter I elaborate on the specific challenges associated with digital innovation in ecosystems, the research approach adopted in this dissertation project, and the outline and output of the three empirical chapters in this thesis.

1.2 An ecosystem approach

The term *ecosystem* has increasingly been used in business practice and academia to refer, broadly, to “the collaborative arrangements through which firms combine their individual offerings into a coherent, customer-facing solution” (Adner, 2006, p. 98). The analogy from biological ecosystems is useful in that for both biological and business ecosystems the overall health, and thereby survival, depends on “a large number of loosely interconnected participants” (Iansati & Levien, 2004, p. 76). The relationships between ecosystem members are complex and intertwined, and the effectiveness of an ecosystem is therefore beyond the control of any single participant. This resembles the dynamics in today's ecosystems that revolve around digital innovations where value comes from the availability of different modules and how well these integrate together, e.g., a break-down in one component or sub-system affects the rest of the system.

In the context of innovation, every ecosystem participant thus creates value by providing one part (or multiple parts) of the overall solution. Baldwin and Woodard (2009) make a useful distinction of *core components* (i.e. the focal product) and *complementary components* (i.e. complements). The core components include the platform technology and interfaces through which the complements connect with the focal product. While the core components are generally stable and fixed, the complements can be interchanged and thereby offer variety to the end-users of the system. To illustrate, a laptop or PC (the core components or platform) can be extended with different peripherals such as a keyboard or mouse (the complements) through standardized USB-ports (the interface). Similarly, the functionality of an iPhone increases when apps (that interact via Apple's Application Programming Interfaces) are installed.

In turn, depending on whether ecosystems participants develop core components or complementary modules, we generally distinguish actors as being the *focal firm* or *complementors* (Adner & Kapoor, 2010). The focal firm (also referred to as key stone, hub or platform leader/owner) is responsible for the development and control of the platform core components and its interfaces (Iansiti & Levien, 2004; Gawer & Cusumano, 2002). The complementors have to comply to the rules set by the focal firm and, depending on the governance model, develop complements to a more or lesser extent independently, and offer these directly or indirectly to the end-users.

These actors involved are organizations from different industries instead of one single industry (Moore, 1993) and may vary considerably in size. To illustrate, mobile ecosystems (e.g., Basole, 2009; Lindgren, Ericsson & Lyytinen, 2015), typically involve an ecosystem of independent third-party developers who contribute complementary applications (apps). These third-party developers can be self-employed professionals seeing a market opportunity, or just hobbyists with a user need who like to develop software in their spare time (i.e., user innovators). At the same time, large network operators and device manufactures are members of the same ecosystem. Despite the differences in power, motivations, and ways of working, these actors need to effectively coordinate and collaborate innovation activities in order to maintain a healthy ecosystem.

In this dissertation I address three successive stages of ecosystem development. Here, I a follow life cycle logic (e.g., Van de Ven & Poole, 1995). This logic builds on a biological metaphor and assumes that organizational entities develop from birth to death, with intermediate stages such as adolescent growth and maturity. Similarly, when applied to (business) ecosystem evolution, Moore (1993), in his influential paper, differentiates between four stages of ecosystem maturity: birth, expansion, leadership, and self-renewal (or when self-renewal does not take place: death). In the context of this dissertation, I distinguish between ecosystems *creation*, *growth,* and *maturity*. I elaborate on each stage and identify key organizational challenges next.

1.2.1 Creating an ecosystem

During ecosystem "birth" (Moore, 1993), the focus is on developing a value proposition for the to-be-developed technology, product and/or service. The value proposition is the "the promised benefit that the target of the effort is to receive" (Adner, 2017, p. 43), and forms the foundation of the ecosystem; members are organized around materializing this value proposition. However, early in ecosystem evolution a clear definition of the value proposition or product is still missing. As a result, nascent ecosystems are characterized by a high level of ambiguity (Santos & Eisenhardt, 2009), which in turn makes coordinating ecosystems members and their activities an organizational challenge.

To complicate matters, the structure of the ecosystem at this point is still highly dynamic, as ecosystem member composition (and each member's role) is subject to change (Hannah, 2015). As a result of this ambiguity and uncertainty, it is hard to envision the blueprint for the ecosystem *ex ante* (Dattée, Alexy & Autio, 2017). This is in particular the case for digital innovation, which is 'incomplete by design' (Garud, Jain & Tuertscher, 2008), because new components can be integrated over time (even after launch) and thereby changing the solution's functionality and meaning (Yoo et al., 2010). Thus, the value proposition and ecosystem composition remains ill defined.

Yet, performance of the to-be-developed integrated solution depends on the collective efforts by all ecosystem actors. For example, a delay in the availability of complements can be detrimental for adoption (Adner & Kapoor, 2010). Specifically for platform-based ecosystems, there needs to be sufficient complements on one side to attract users on the other side of the platform, and the other way around (a 'chicken-and-egg problem'). It is therefore of key importance to coordinate activities during early stages of ecosystem evolution.

Following the ecosystem-as-structure perspective by Adner (2017), the alignment of partners and their activities is a challenge that results from the interdependency among members. These members are heterogeneous in nature, for example, depending on their industry, tenure, and motivations, organizations differ in how they organize their innovation trajectories. Large, incumbents may follow different longer but slower cycles as compared to start-ups. Such sources of differences require effective alignment in order to avoid conflict. Because of the dynamic nature of emerging ecosystems, this coordination challenge is in particular compounded.

Thus, uncertainty and ambiguity in early stage of ecosystem creation on the one hand, and the heterogeneous nature of ecosystem actors on the other, result in complexities that need to be coordinated. Chapter 2 empirically investigates this ecosystem coordination challenge, building on an in-depth qualitative field study of a smart city project.

1.2.2 Growing an ecosystem

Once the ecosystem is created and the central value proposition is more or less defined, the next step is to attract and involve sufficient number of complementors to materialize the envisioned integrated solution. Thus, during the next phase of ecosystem evolution, i.e. the “expansion” stage (Moore, 1993), it is of key importance to *grow* the ecosystem of complementors to create large enough variety of options for additional value of the overall system.

Research on platform-based ecosystems has been in particular concerned with the challenge of having sufficient number of complements, because platforms (from an economics perspective) are characterized by thriving on *network effects* (or network externalities) (e.g., Gawer, 2014). Network effects take place when a platform becomes increasingly attractive when more participants join. We can distinguish between direct or indirect network effects. First, direct network effects refer to same-side externalities, for example, when more users adopt WhatsApp, the service becomes more valuable to other users. Second, indirect externalities happen when two sides of a platform interact, e.g., video game developers are more interested in developing and publishing games for a console platform when there are more users, while users typically gain more value from a platform when more video games are available. Digital product platforms typically involve multiple sides—demand and supply (with users on the hand and complementors on the other)—and are therefore subject to indirect network effects.

As a result of this positive, reinforcing relation, platform owners employ different tactics to have potential complementors choose and develop for their particular platform. Increasingly, platform owners decide to (partially) open up their platform by giving outsiders (a certain degree of) access to the interfaces (typically APIs). Boudreau (2010) found that such an open platform strategy accelerates the development and introduction of complementary innovation. At the same time, opening up also means giving up some control over who can join the ecosystem and what complements are developed (e.g., Boudreau, 2010; Wareham et al., 2014). Research has indicated that platform owners therefore need to employ mechanisms of appropriate formal and informal control to govern innovation by complementors, for example through providing boundary resources such as API (application programming interface) documentation (Ghazawneh & Henfridsson, 2013), or through strict reviewing of complements and tight membership rules before letting them in (e.g., Tiwana, 2013).

Prior research has mainly considered the role of the focal firm in governing and controlling complementors. However, control is never solely with the focal firm, as complementors continue to have control over their own assets (Jacobides, Cennamo and Gawer, 2018). For digital innovations, complementors may even have more influence over the ecosystem as they can also create connections *across* systems. That is, in developing complementary products and services for the focal platform they become part of multiple ecosystems by e.g., recombining APIs. In doing so they create connections *beyond* the control of the central platform owner. The fact that complementors create such connections across digital platforms calls for next level considerations with regards to managing, incentivizing and controlling the ecosystem of complementors.

Thus, during stages of ecosystem growth a key organizational challenge is to manage these relationships with complementors, in particular given the far-reaching influence complementors have with regards to the overall product integrations and usage value. Appropriate modes of coordination may range from autonomous interaction with complementors taking place at arm's length through open interfaces and boundary resources, to more intensive and direct collaboration through partnerships (desired for e.g. marketing purposes or tighter integration between components).

Chapter 3 explores how Philips manages its ecosystem of complementors in relation to the Hue connected light bulb system, with special attention to the technical integrations between the platform core components and complementary products over time.

1.2.3 Maintaining a mature ecosystem

When an ecosystem reaches maturity, the aforementioned initial hurdles are overcome, but new challenges arise. In particular, established ecosystems face "leadership" challenges (Moore, 1993), that is, to stay a leader, the focal firm must defeat competing ecosystems. While a successful ecosystem has reached sufficient base of complementors to offer a variety of functionality to satisfy user needs, still, continuous innovation is necessary to stay ahead of competitors.

In the context of platform-based ecosystems, Cusumano and Gawer (2002) indicate three potential problems platform leaders face: "First is how to maintain the integrity of the platform (the compatibility with complementary products) in the face of future technological innovation and the independent product strategies of other companies. A related problem is how to let platforms evolve technologically (as they must or become obsolete) while maintaining compatibility with past complements. A third problem is how to maintain platform leadership." These problems call for both technical and strategic consideration.

From a technical point of view, it has been generally accepted that platforms should follow a modular architecture (e.g., Baldwin & Clark, 2000), with stable core components and a periphery of ever evolving complementary components (e.g., Baldwin & Woodard, 2009). Innovation thus takes place via complementary components that interact with the core platform through standardized interfaces. Therefore, the interfaces should remain fixed so that smooth integration is ensured. However, Gawer (2014) notes that the "reality of platform dynamics" is more complex, and that we should take into account platforms themselves evolve too. For instance, a platforms' architecture can shift towards increasing or decreasing modularity, e.g., a more integrated and pre-assembled solution may be of better performance and easier for users (Schilling, 2000). Furthermore, platforms owners can allow for a certain degree of backward compatibility when launching new generation of the platform core components, so that older complements still integrate with newer versions (Eisenmann et al., 2009; Hann et al., 2016).

This means that platform owners need to make strategic choices in how they manage such platform evolution dynamics. To illustrate, Apple and Android follow different strategies in this regard. Apple offers more integrated solutions in order to offer their users the ultimate, smooth user experience. Furthermore, Apple offers less backward compatibility for newer version of their operating systems compared to Android. As a result, Android users are more flexible in that they can continue to use older apps, but it also means that fewer users switch to a new generation.

When platform core components evolve, this also has implications for the complementors. First, platform owners may decide to integrate functionality previously provided by complementors in the core of the system (e.g., Evans et al., 2006). When such envelopment takes place, complements become obsolete. Second, when platform and associated interfaces change, it may involve that complementors also need to update their products to maintain interoperability with the latest platform generation (Tiwana, 2016). Taken together, complementors need to carry out maintenance work to ensure the quality performance of their complements both with regards to functionality and system integrity.

Chapter 4 focuses on the temporal dimensions of complement quality given that the platform evolves over time. Building on a study on the Philips Hue platform and its complementary third-party apps, we unpack maintenance work (in the form of different updating practices) by third-party developers.

1.2 Research approach

1.2.1 A process perspective

To understand these aforementioned organizational challenges associated with digital innovation in ecosystems, I adopt a *process research approach* (e.g., Langley et al., 2013). Process research differentiates from other types of research (such as cross-sectional or variance research) in the way time is treated: process research places specific emphasis on the role of time on the phenomena it tries to explain (e.g., Van de Ven, 2007). In the context of this dissertation this means that I do not treat

Table 1-1 Overview of key organizational challenges for stages of ecosystem evolution

	Creating an ecosystem Nascent ecosystems are characterized by ambiguityanduncertainty around the overall value proposition.	**Growing an ecosystem** In the growth stage, value is created when a varietyofcomplementors developcomplementary products and services that integrate with the focal platform.	**Maintaining a mature ecosystem** Matureecosystemshave reached sufficient user andcomplementorbase but requires constant innovation to stay competitive.
Organizational challenge	*Coordination:* Alignment of activities is necessary to develop a coherent value proposition (Adner, 2017) and kick-start an innovation ecosystem. However, ecosystems involve heterogeneousgroupof organizations, resulting in differences that may leadtocomplexitiesthat hinder the process of collaborativeinnovation. Given the ambiguity of nascentecosystems,this coordinationchallengeis compounded.	*Management of complementors:* Through (partially) open and standardized interfaces, third-party complementaryproducts and service integrate with the focal platform components. Besides technical integration, the focal firm needs to find appropriate ways to manage the organizational connections, i.e. the relations with complementorsintheir ecosystem(e.g.,ranging from autonomous developmenttointensive partnerships).	*Maintenance:* When platform core componentsevolve,the qualityofcomplements alsoneedstobeensured over time. A central issue for platform owners in this stage is make sure that the independent third-party complementors carry out maintenance work to ensure smooth integration as well as complementary functionality.

ecosystems as static and fixed entities, instead I am interested in better understanding how a platform architecture evolves over time (Gawer, 2014) as well as unpacking the underlying (micro) processes of collaborative value creation in innovation ecosystems (Autio & Thomas, 2013). Furthermore, since digital innovations are malleable and generative, their meaning is in constant flux (e.g., Yoo et al., 2010); adopting a process perspective is therefore well suited to capture the dynamic nature of organizing ecosystems for digital innovation.

Since the purpose of this dissertation research is to develop process theory on how ecosystems for digital innovation are organized, I adopted a qualitative inductive approach to data collections and analysis. Here I follow Langley and Abdallah (2011, p. 202) who argue: "qualitative data have particular strengths for understanding processes because of their capacity to capture temporally evolving phenomena in rich detail." While quantitative data could also generate process theory, qualitative data (or a combination of both) generally provides richer and more detailed insights (Langley, 2007).

1.2.2 Field research

My desire to gather in-depth and inductive insights about organizational dynamics has led me to do what can best be labeled as *field research*. When doing field research, the researcher is embedded in an organizational context. In my case I was (physically) present in the research setting for a longer period of time. I had an access badge and corporate e-mail address so that I could move around freely in the organization. Furthermore, I could use one of the available desks on the days that I was in the office, and have informal coffee and lunch talks with the people from the organization. As I became immersed in the organization, I was able to better understand and capture events in context. In addition, being embedded in the organization allowed me to build trust and a long-lasting relationship with informants over time, which aided data collection and analysis.

The rationale for this form is research is in-line with the principles of "engaged scholarship" by Van de Ven (2007). He argues: "Instead of viewing organizations and clients as data collection sites and funding sources, an engaged scholar views them as a learning workplace (idea factory) where practitioners and scholars co-produce knowledge" (Van de Ven, 2007, p. 7). Through repeated and constant interaction with the people within the organization I refined my initial, general research question (based on theory) into more relevant and well-structured problem formulations. When more familiarized with the phenomena of managing digital innovation activities in practice, and through engaging with key stakeholders, I was able to 'ground the problem in reality'.

Field research allowed me to gather a variety of in-depth qualitative data. First I performed observations at the research site. Such observations included being in meetings as 'a fly on the wall' and attending public presentations and events as well as internal company presentations. I made field notes to capture my impressions and reflections. A second key source of information were semi-structured interviews with people who were or had been involved in the innovation trajectory that I studied, from within the company as well as external (e.g., independent third-party app developers). Key informants were interviewed multiple times. Additionally, I had numerous informal conversations at my days in the field, allowing for more ad-hoc (clarification) questions. In addition, I collected available secondary data, such as news articles, press releases, blog posts, and presentations slides, which gave additional insight in the different stakeholder dynamics. Lastly, release notes about updates in the system and complementary apps provided insightful information to better understand the technical side of organizing digital innovation.

My data collection and analysis, following a process research approach, focused primarily on (sequences of) *events*, i.e. "what key actors do or what happens to them" (Van de Ven, 2007, p. 155). When analyzing my data I created timelines of these events and searched for patterns over time (Langley, 1999). Furthermore, my data collection and analysis followed a typical iterative process in which I went back and forth between my data and theory. The specific procedures of data collections and analysis will be discussed in the specific chapters of this thesis.

1.2.3 Research setting

To answer the main research question of thesis I performed two field studies. First, I investigated a local innovation ecosystem revolving around the development of smart city solutions in a Dutch municipality. Broadly defined, the goal of the ecosystem was to make use of novel digital technologies to improve the atmosphere and safety in a problematic nightlife area in the city center. The municipality, together with a local university, technology companies (SMEs and internationals), and knowledge institutes formed the core of the ecosystem. Over time new parties joined and others became less present. Several pilots were performed through collaborative arrangements among ecosystem members. For example, analysts analyzed very large set of (big) data (e.g., social media messages) to measure the atmosphere real-time (e.g., positive or negative), to ultimately, when combined with other types of data (such as the number of visitors and weather), predict when and where violent incidents would most likely take place.

Study 1 focuses on coordination among the heterogeneous group of actors and multitude of technological advanced solutions was of critical importance for long-term survival. Members have their own incentives to join the initiative (i.e., what to get out of the collaboration). In addition, they are embedded in their own ways of working and industry structures. Furthermore, to integrate the different digital technologies into one smart city system, alignment is of critical importance in order to avoid inter-operability issues. Taken together, this setting is suitable to study how to deal with the coordination challenge in nascent ecosystems.

The second research setting is situated in the smart home, where I studied the dynamics around the Philips Hue ecosystem. The Philips Hue is a consumer connected lighting product that can be controlled from a smart phone or tablet. The Hue system was released in October 2012, and has been a huge success ever since (today the bulbs are the leader in smart lighting). The Hue is compatible with today's most prominent smart home systems, including Apple's HomeKit, Google Home and Amazon Echo. In addition, independent third-party app developers worldwide have developed hundreds of integrations through the open API program.

The transformation from 'dumb' incandescence light to smart LEDs bulbs is a prime example of digital innovation. The management of Philips Lighting was confronted with the entrance of a large number of various complementors who continued to innovate and redefine the product user value after the Hue was put on the market. Study 2 addresses the different ways in Philips Lighting approached outside innovation on their platform, and successfully managed the relations with their complementors during ecosystem growth. In study 3 we zoom in on the third-party app developers and unpack the dynamics of maintenance through updating activities, which is a key issue since the Philips Hue platform ecosystem reached maturity.

1.3 Dissertation outline

Next to an introductory and concluding chapter (Chapter 1 and 5), this thesis comprises three chapters that report on empirical studies (see Table 1-2 for an overview). The three chapters are written (and can be read) as separate articles, and have been presented at various conferences, seminars and workshops. Because these papers are co-authored, I refer to 'we' in the respective chapters.

Chapter 2 zooms in on the coordination challenge for nascent ecosystems. The process approach is reflected in the special attention to coordinating temporal differences among ecosystem members. That is, each organization has its own temporal structure, and conflicts may arise when these temporal structures are not aligned. We investigate how temporal coordination is achieved through a field study of an ecosystem of heterogeneous actors who innovate together to develop smart city solutions. In analyzing our longitudinal data we traced episodes (series of events) in which the involved stakeholders effectively bridged temporal differences. In this paper we build on the time research literature, which has predominantly advocated for alignment through adaptive synchronization. We present three additional strategies for temporal coordination in innovation ecosystems that complement current insights on synchronization.

Chapter 3 focuses on the management of digital platforms and examines the interaction between the platform owner and various complementors in the ecosystem. Through a case study of the Philips Hue ecosystem, we show how complementors connect with the Hue platform as well as other associated platforms, beyond the control of platform owner Philips Lighting – an important insight that has so far not been explicitly addressed in the literature. Complementors thus do not only add value to a platform by developing complementary services and products, but also play an important role by integrating different platforms (for example by recombining APIs). We discuss the consequences for both the integrity of the overall system and the implications for how platforms owners manage the relationships with their complementors.

Chapter 4 expands Chapter 3 by zooming in on the third-party apps (and their developers) in the Philips Hue ecosystem. We show that for mature ecosystems, the maintenance of complements is of key importance to ensure the overall quality of the system. Stated differently, large quantities of complements do not add much value to a platform when they no longer integrate well with newer versions of the platform or when their functionality becomes obsolete because others catch up. As a result, there is a need to keep the independent app developers engaged with a platform for a longer period of time, and to make sure that they continue to perform necessary updates to their apps. We elaborate on the different types of updating practices, the developers' rationales for doing such updates (or not), and the role of the platform owner and users in this process.

Table 1-2 Overview of chapters and related output

Chapter	Purpose & research question	Related output	Co-authors
1. Introduction	The introductory chapter presents the main research question for this dissertation, embedded in current literature on digital innovation and ecosystem evolution, and introduces the research approach that was adopted.	-	-
2. In- and out-of-sync: Temporal coordination in innovation ecosystems	This chapter aims to understand alignment of ecosystem participants in nascent ecosystems. Through a study on a smart city initiative, we answer the research question: How do organizations achieve temporal coordination in emerging innovation ecosystems?	An earlier version has been presented at European Group for Organizing Studies Conference 2015 (Athens, Greece).	Hans Berends, Fleur Deken, Philipp Tuertscher, Marleen Huysman
3. Complementors as connectors: Managing open Innovation around digital product platforms	The purpose of this chapter is to unpack the organizational dynamics in growing ecosystems, and addresses the following specific research question: How do platform owners and external actors manage a variety of connections between digital products?	An earlier version has been presented at the ABRI PhD Day (March 2016, VU Amsterdam) and the Academy of Management Specialized Conference on Big Data 2018 (Surrey, UK). The paper currently under review at R&D Management Journal (R&R).	Hans Berends, Fleur Deken, Philipp Tuertscher

4. Gardening a thousand flowers: Ensuring complement quality over time in the Philips Hue ecosystem	This chapter addresses the importance of maintenance for mature digital platform ecosystems. We ask: how is the quality of complementary products and services in digital platform ecosystems ensured over time? The answer to this question is based on empirical research on third-party apps for the Philips Hue.	Earlier versions have been presented at the Open and User Innovation conference 2016 (Boston, USA), RATIO workshop for Young Social Scientists 2016 (Stockholm, Sweden), and Academy of Management Annual Meeting 2017 (Atlanta, USA).	Hans Berends, Fleur Deken, Philipp Tuertscher, Marleen Huysman
5. Discussion	The last chapter of this dissertation summarizes the key findings, theoretical contributions, suggestions for future research and practical implications. The chapter ends with a methodological reflection.	Parts of the methodological reflection on studying time is based on a literature review that was presented at the European Group for Organizing Studies Conference 2014 (Rotterdam, The Netherlands).	-