Managing Competitive and Cooperative Strategizing in Open Platform Ecosystems using Boundary Resources

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A doctoral dissertation completed for the degree of Doctor of Science (Technology) to be defended, with the permission of the Aalto University School of Science, at a public examination held at the lecture hall T2 of the school on 14 January 2016 at 12.

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Abstract

Digitalization is proliferating and digital strategizing is thus becoming ever more important in various industries. Digital business is increasingly based on use of open platforms counting on complements from 3rd parties and network effects they induce. Existing research on open innovation and open platforms have mainly focused on positive leverage effects of openness and have neglected the negative aspects, such as competitive threats caused by openness. Motivated by these notions, this dissertation studies how platform owners can manage both cooperative and competitive challenges and strategize in open platform ecosystems.

This dissertation is composed of four articles and a summary synthesizing the results. Mobile industry, being one of the forerunners in digitalization, was chosen as the focal case for the study. The study was organized as a multiple case study, in which each article extended and enriched the analysis of previous articles. As a whole, they form a large case study of mobile industry spanning from 2007 to 2015 covering all major mobile platforms.

This dissertation makes three contributions. First, open platform ecosystems are depicted as a new kind of competitive environment with platform forking identified as a specific new form of competition and strategic challenge for platform owners. Second, boundary resources are enriched to be the central strategic tools that are actively used to manage both cooperation and competition with the various actors of the open platform ecosystem. To manage cooperation, boundary resources are exposed as versatile strategic tools to attract, control, and appropriate value from the complementors. From competition perspective, too open boundary resources may be strategically exploited through platform forking to build a competing platform. To counter the competition, platform owner can use boundary resources to defend against exploiters. Third, as a conclusion, boundary resources are reasoned to have a central role in building and sustaining competitive advantage in open platform ecosystem.

Finally, to help managers to cope with open platform strategizing and think strategically about boundary resources, several managerial implications are derived from the findings. To prevent exploitation, managers are advised to pay close attention in designing the boundary resources in the first place; both by balancing between generative effect and minimizing risks and by leaving room for strategic maneuvering at a later point of time if needed. A key managerial advice is that digital tools should be used increasingly in strategizing. Google Play Services illustrates that software technological strategizing offers additional benefits including rapid deployment, customizability and precise targeting.

Tiivistelmä

Digitalisaatio leviää, ja sitä myötä digitaalinen strategiointi nousee yhä tärkeämpään rooliin monella toimialalla. Digitaalinen liiketoiminta perustuu kasvavissa määrin avoimien alustojen käyttöön. Avoimen alustan liiketoimintamalli nojaa kolmansien osapuolien täydentäviin tuotoksiin ja niiden avulla syntyviin verkostovaikutuksiin. Aikaisempi tutkimus avoimesta innovaatiosta ja avoimista alustoista on pääosin keskittynyt näihin myönteisiin kerrannaisvaikutuksiin ja ohittanut kielteiset vaikutukset, kuten liiallisen avoimuuden aiheuttamat uhat. Tämän tutkimusaukon täyttämiseksi tämä väitös tutki, miten alustan omistaja voi hallinnoida sekä yhteistyölliset että kilpailulliset haasteet avoimen alustan strategiassaan.

Väitös koostuu neljästä artikkelista ja yhteenvedosta, joka syntetisoi tulokset. Kohdetoimialaksi tutkimukselle valittiin mobiilitoimiala, jossa digitalisaatio on jo edennyt pitkälle. Tutkimusmenetelmä oli monitapaustutkimus, jossa kukin artikkeli rikasti analyysiä joko uusilla tapauksilla tai syvensi aiempia. Kokonaisuutena työ muodostaa laajan tapaustutkimuksen mobiilitoimialasta vuodesta 2007 vuoteen 2015 kattaen kaikki merkittävimmät mobiilialustat.

Väitös tekee kolme tutkimuksellista kontribuutiota. Ensinnäkin avoimen alustan ekosysteemi kuvataan uudenlaisena kilpailullisena ympäristönä ja alustan haaroittaminen nostetaan esiin erityisenä uutena kilpailullisena uhkana alustan omistajalle. Toisekseen rajaresurssit esitetään keskeiseksi strategiseksi työkaluksi, jolla hallinnoidaan sekä yhteistyötä että kilpailua eri toimijoiden suhteen avoimen alustan ekosysteemissä. Tähän liittyen rajaresurssit ovat monipuolinen työkalu houkutella ja kontrolloida yhteistyökumppaneita sekä luoda arvoa heidän kanssaan. Toisaalta kilpailijat saattavat hyväksikäyttää liian avoimia rajaresursseja ja luoda kilpailevan haarautetun alustan. Vastatakseen tähän alustan omistaja voi myös käyttää rajaresursseja puolustautumiseen. Kolmantena kontribuutiona yhteenvetona esitetään, että rajaresursseilla on laajemmin keskeinen rooli kilpailuedun muodostumisessa ja ylläpitämisessä avoimen alustan ekosysteemissä.

Työn lopuksi esitetään konkreettisia johdon toimenpiteitä avoimen alustan strategiointiin. Estääkseen resurssien väärinkäyttöä rajaresurssien suunnitteluun on panostettava heti alussa. Tämä tarkoittaa sekä kerrannaisvaikutuksien ja riskien välillä tasapainoilemista että myöhempien strategisten liikkeiden mahdollistamista. Työn keskeinen havainto on, että rajaresurssit ja ylipäänsä digitaaliset työkalut tarjoavat uuden näkökulman strategiointiin. Google Play Services on yksi hyvä esimerkki siitä, miten digitaalinen strategiointi mahdollistaa strategian nopeamman toimeenpanon, muokattavuuden ja tarkemman kohdennuksen.

Avainsanat alustan haaroittaminen, avoin alusta, digitalisaatio, rajaresurssit, strategiointi

Preface

I have been privileged to have supervision from three professors for this thesis work. First of all, this work would have not even started without Professor (pro tem) Matti Hämäläinen proposing me to jump from the industry to the academic world to start the research work. I am grateful to Matti for providing me this opportunity, taking care of the funding side, and inspiring and supervising my work during the first years. Secondly, at the critical stage of my work, I was fortunate to meet Assistant Professor Robin Gustafsson when attending a strategy class. Robin became a co-author for my final article and also the second supervisor for my dissertation. I am truly grateful to Robin for pushing my thinking further and helping me to crystallize the contribution of my work. Finally, I want to sincerely thank Professor Martti Mäntylä who took the supervising baton at the final critical stages of my work, engaged in insightful discussions, and helped to push everything together.

As any academic work, this dissertation has been a collaborative effort. I wish to thank the co-authors of the articles for this dissertation, Tingan Tang, Andrea Botero, and Sami Vihavainen for their contributions, insights and collegial support. This work has also greatly benefited from discussions with various colleagues at the CS department, Mikko Heiskala, Seppo Törmä, Petri Mannonen, Kari Hiekkanen, Janne Korhonen, Mika Helenius, Timo Itälä, Junying Zhong, Ilkka Melleri, and several others I have had the privilege to work with.

I owe special gratitude to the pre-examiners of my dissertation, Professor Ola Henfridsson of the University of Warwick and Professor Martin Kenney of the University of California, Davis for their insightful comments and suggestions to improve this work. Further, I am honored to have Professor Kalle Lyytinen of Case Western Reserve University as the opponent of my dissertation.

Finally, I want to thank my family, my farther, my two brothers and sister, and especially my loving wife, for their encouragement and unwavering support during the journey.

Enjoy reading!

Helsinki, December 15, 2016,

Kimmo Karhu

Contents

List of Publications

This thesis consists of an overview and of the following publications which are referred to in the text by their Roman numerals.

I Kimmo Karhu, Andrea Botero, Sami Vihavainen, Tingan Tang and Matti Hämäläinen. A Digital Ecosystem for Co-Creating Business with People. *Journal of Emerging Technologies in Web Intelligence*, Vol. 3, No. 3, Pages 197-205, August 2011.

II Kimmo Karhu and Tingan Tang. A Comparison of Digital Business Ecosystems Built around Global Smart Phone Application Stores. In *Proceedings of Joint Conference on eServices and Business Intelligence 2010 (JCeSBI 2010)*, Chengdu, China, June 2010.

III Kimmo Karhu, Tingan Tang and Matti Hämäläinen. Analyzing competitive and collaborative differences among mobile ecosystems using abstracted strategy networks. *Telematics and Informatics*, Vol. 31, Iss. 2, Pages 319-333, May 2014.

IV Kimmo Karhu and Robin Gustafsson. Open Platform Boundary Resources as Arenas for Strategic Exploitation. *Academy of Management Annual Meeting 2015 (revised version under review at ISR)*, Vancouver, Canada, August 2015.

Author's Contribution

Publication I: "A Digital Ecosystem for Co-Creating Business with People"

Kimmo Karhu was behind the research idea for this article, conducted the data collection and analysis, and was in overall charge and wrote most of the article. Andrea Botero wrote "New actors in value co-creation and innovation processes" section. All authors reviewed the whole article and provided comments and feedback.

Publication II: "A Comparison of Digital Business Ecosystems Built around Global Smart Phone Application Stores"

Kimmo Karhu was behind the research idea, conducted most of the data collection and analysis, and almost solely wrote the article. Tingan Tang contributed the analysis of Chinese case, reviewed the whole article, and provided comments and feedback.

Publication III: "Analyzing competitive and collaborative differences among mobile ecosystems using abstracted strategy networks"

Kimmo Karhu was behind the research idea for this article and almost solely wrote the article. All authors reviewed the whole article and provided comments and feedback.

Publication IV: "Open Platform Boundary Resources as Arenas for Strategic Exploitation"

Kimmo Karhu was behind the research idea for this article, conducted the data collection and analysis, and was in overall charge and wrote most of the article. Robin Gustafsson contributed to all sections of the article, specifically theory and contribution part, reviewed the whole article, and provided comments and feedback throughout the writing process.

1. Introduction

This section introduces the background and context of the thesis, motivates the research both from science and business perspectives, defines the research objectives, and presents the structure of the thesis.

1.1 Background

Society and economy are becoming increasingly digitalized. The mobile phone business provides an illustrative example of digitalization from the last 30 years. The mobile phone has progressed from a device to make wireless calls over analog NMT networks to using digitalized medium, GSM network, and during the last decade has transformed into a smartphone, a central artifact of our life through which we produce and consume digital content, such as applications.

In this transformation, the mobile industry has changed from being device and operator driven into being dominated by software firms, such as Apple and Google. These firms base their business on a platform strategy building vibrant business ecosystems around their platforms. The dominant approach has been to open up the platform and cooperate with third parties to attract complements. Levels of openness and cooperation range from Apple's restricted cooperation with selected actors, such as developers, to Google's open platform strategy in which majority of the platform stack is open and available to any actor.

At the same time with a cooperative approach, platform firms fiercely compete in business, not only with each other, but also with their own complementors. Firms use coopetitive strategies in which competition and cooperation are simultaneously present and may realize towards the same actor in the ecosystem. Furthermore, increased openness has led to an emergence of platform forks, such as Amazon Fire, who exploit

open platforms and build a forked platform competing in business with the host. Open platform ecosystem is a new kind of competitive environment in which firms need to rethink how they manage the cooperative and competitive strategizing and the strategic interplay between them.

1.2   Motivation

The new competitive environment around digitalized products, often built using open platforms, poses management challenges for platform owners (Porter and Heppelmann, 2014). In an ever more digitalized world, platformization doesn't only concern the established big players, but also firms of all sizes in a variety of industries. Digital platform-based business models, and specifically open platform strategies, the central theme in this thesis, can be expected to proliferate.

Existing open platform (Boudreau, 2010) and open innovation (for recent review see West and Bogers, 2014) research have mainly focused on positive impacts such as generativity and leverage aspects enabled by openness (Thomas et al., 2014). West and Bogers (2014) specifically note that few researchers have identified negative impacts. Dahlander's and Gann's (2010, p. 706) call for future research on costs of an actor acting "opportunistically in bad faith" is still largely unanswered. Yoo et al. (2012, p. 1406) also note the risks and need for organizations "to learn how to compete and thrive in this new world." Motivated by these notions, this thesis also studies the negative impacts and new forms of competition such as strategic exploitation by the platform forks.

A second gap in the research motivating this thesis relates to coopetition, i.e., combination of cooperation and competition, in the open platform environment. This thesis addresses three specific calls for research that Bengtsson and Kock (2014) list in their recent review on coopetition: balancing of cooperation and competition, applying a multilevel perspective, and understanding the dynamics of coopetitive interaction.

Apart from scientific impact, new forms of digital strategizing, such as platform forking, also have significant impact on business. As an example, Amazon and Xiaomi have built their respective proprietary platforms by forking the Android Open-Source Project (AOSP) and have succeeded in acquiring complementors from the official Google Android for their platforms (Pon et al., 2014). Even using estimates on the low side (Barnett, 2011), a forked platform saves 1-2 billion dollars in development costs

(and keeps saving for each subsequent version) and can boost its app store with hundreds of thousands of ready-made apps that developers can potentially migrate to it. Furthermore, according to various analyst reports, smartphones that use a forked Android platform already comprise more than 20 percent of total shipments and thus constitute approximately 25 percent of Android's market share.

Business impacts are also illustrated through an ongoing legal dispute between Oracle and Google in relation to using Java application programming interfaces (APIs) for Android. In the second round of court proceedings, Oracle asked for a staggering $9B in damages, but the District Court has so far ruled that Google's copying of Java APIs adhered to fair-use principles. Digital strategizing is ever more important and can potentially have a significant impact on a firm's platform business.

1.3 Research objectives

The main aim of this thesis is to study how digital platform firms can manage both cooperative and competitive strategizing and the resulting strategic interplay in the platform ecosystems. The mobile industry is a forerunner in digitalization and platformization and is thus chosen as the context for this thesis. Studying strategizing in mobile industry context and aiming to generalize early findings from such an analysis is highly relevant because digitalization is spreading to other fields of business, and thus the same strategic challenges will emerge there.

The overall research question for this thesis is: How can platform owners manage cooperative and competitive strategic interplay in the platform ecosystem? This thesis studies developments in mobile business and aims to derive concrete managerial advice on how firms *can* strategize. The focus of this thesis is on *strategic interplay*, both in the meaning of combination of cooperation and competition and as forming an enduring relationship between the actors either within or between the platform ecosystems. This thesis focuses on *platform ecosystems*, business ecosystems built around a digital platform.

The overall research question is further divided into four research subquestions as listed in Table 1.1. Each research question is primarily answered with one publication, marked with a roman numeral in the second column, and the support of findings from another publication is referred to in parentheses. Each publication thus provides a partial solution to the

research problem, and their contributions are combined in this dissertation summary.[1].

Table 1.1. How research questions are answered by each publication

Overall research question: How can platform owners manage cooperative and competitive strategic interplay in the platform ecosystem?	
Research sub-questions	**Publications that answers**
RQ1: Who are the key actors in a platform ecosystem around the mobile platform?	I + (II, III)
RQ2: What are the main digital elements of a mobile platform and their strategic design purposes?	IV + (I)
RQ3: How do mobile platform owners cooperate and compete with other actors in their platform ecosystem?	III + (II)
RQ4: How do mobile platform owners manage cooperative and competitive strategizing towards other platform firms?	IV

The first two research sub-questions focus on structures and entities in the platform ecosystem. The first research sub-question (RQ1), "Who are the key actors in a platform ecosystem around mobile platform?", aims to identify the human, organizational, and digital actors in the platform ecosystem and is mainly answered by Publication I with refined findings from Publications II and III. The second research sub-question (RQ2), "What are the main digital elements of a mobile platform and their strategic design purposes?", in turn digs into the innards of digital platform and is primarily answered by Publication IV supported with some preliminary results from Publication I.

The latter two research sub-questions focus on strategic actions and events. The third research sub-question (RQ3), "How do mobile platform owners cooperate and compete with other actors in their platform

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[1]This thesis is a compilation thesis and thus by definition it heavily relies on original publications (I-IV) attached herein. Illustrations and text adapted from the original publications are referred with roman numerals. For the sake of readability, copied extracts as part of these adaptations from original publications have not been quoted.

ecosystem?", aims at revealing the competitive and cooperative strategizing within a platform ecosystem and is primarily answered by Publication III, supported by preliminary findings from Publication II. Finally, the fourth research sub-question (RQ4), "How do mobile platform owners manage cooperative and competitive strategizing towards other platform firms?", is answered by Publication IV and extends the view to strategic interplay between platform ecosystems.

1.4   Structure of the document

The remainder of the thesis is structured as follows. Chapter 2, Theoretical Foundation, provides a compact review and synthesis of related research upon which this thesis builds. Chapter 3, Materials and Methods, describes the case study method used and illustrates the cases and materials selected for the study. Chapter 4, Results, presents the findings from all the original publications answering the research questions set for this thesis. The Results section is divided into five sub-sections that answer each of the four research sub-questions in turn and then summarize the results. Finally, Chapter 5, Discussion, identifies the contributions of this study, develops managerial implications, and discusses validity, limitations, and possibilities for future research.

2. Theoretical Foundation

The following theory section synthesizes three streams of existing literature to build a theoretical basis for understanding open platform strategizing. The first section reviews how firms increasingly combine cooperation and competition in their platform strategy. The second section focuses on open platform strategy and the tools and means used by the platform owner firm to govern the platform and its openness. Finally, third section identifies the threats related to too open platform strategy.

Theories related to this thesis come both from the strategy research domain and from information systems (IS) research. These two research fields quite often discuss the same topics using separate concepts. One purpose of the following theory section is to interweave these two fields and synthesize the concepts. For this purpose, instead of providing an exhaustive review of existing literature, the following synthesis will focus on key references in both fields.

2.1 Competitive and cooperative strategizing in platform ecosystems

Mobile business can be viewed organized as business ecosystems (Moore, 1993, 1996), also termed as innovation ecosystems (Adner, 2006; Adner and Kapoor, 2010) or interfirm networks (Uzzi, 1997). In a business ecosystem, a firm works cooperatively and competitively with other actors to co-evolve new products and innovations (Moore, 1993). Business ecosystems develop in stages, each having different competitive and cooperative managerial challenges (Moore, 1993). Firms thus have both competitive and cooperative orientation and can use a syncretic rent-seeking approach to simultaneously compete with rivals while cooperating with other firms (Lado et al., 1997). Simultaneous competition and coopera-

tion has been termed as coopetition (Nalebuff and Brandenburger, 1996; Bengtsson and Kock, 2000).

Mobile ecosystems are typically formed around keystone players (Iansiti and Levien, 2004), or in the context of this thesis, often termed platform leaders (Gawer and Cusumano, 2002) or platform owners (Gawer and Henderson, 2007). Platform owners build and control industry-wide technological platform (Gawer and Cusumano, 2002) on top of which complementors, such as app developers and device manufacturers, can develop complementary products that add to the value experienced by its users (Gawer and Henderson, 2007). These actors organizing around the platform together form platform ecosystems (Tiwana et al., 2010; Alstyne et al., 2016).

In essence, mobile platform is a multi-sided platform (Hagiu, 2014). Multi-sided platforms are characterized through two distinctive features, enabling direct interaction between the different sides of the platform and fostering cross-side network effects between the sides (Hagiu, 2014). For example in mobile platforms, users find apps (developed by third parties) through the app store, and the amount of apps available for the platform has a positive network effect on the amount of users.

Literature about two-sided markets (e.g., Eisenmann et al., 2008; Alstyne et al., 2016) further separates platform owners into sponsor and provider roles in which providers serve the interface for different sides of the platform and sponsors do not directly deal with them. According to this view, device manufacturers are viewed as providers for mobile platforms (Alstyne et al., 2016). In line with the multi-sided platform view, this thesis instead regards device manufacturers as one of the complementor sides for the platform along with the developers.

Taken together, the rest of this thesis uses the term *platform ecosystem* to refer to business ecosystems built around mobile platforms. *Platform owner* refers to the platform leader firm, such as Google or Apple, controlling the platform. As the terms cooperation and collaboration are often used interchangeably, this thesis employs the approach used by Polenske (2004) and views *collaboration* as a closer exclusionary relationship to designing, producing, and marketing a product together, whereas *cooperation* is a non-exclusionary external arrangement and thus in general more fitting for the platform ecosystem setting. More over, in line with Ritala et al's (2014) theorization on coopetition, firms can be viewed as cooperating to create value and then appropriating the value through competition. For

the rest of this thesis, cooperation and competition are understood along this definition.

2.2   Governing openness of digital platform

Mobile ecosystems are examples of utilizing open innovation approach, in which firm draws on resources outside its own boundaries (for recent review see West and Bogers, 2014). To create and capture value from external actors, the platform owner has to purposefully orchestrate the innovation network (Dhanaraj and Parkhe, 2006). Mobile platforms are examples of digital innovations, i.e., product innovations that rely on digitization, involving "the encoding of analog information into digital format" (Yoo et al., 2010, p. 725). For digital innovations, digital technology plays a central role in orchestration (Yoo et al., 2012).

In contrast to the platform perspective adopted by strategy research, IS literature has traditionally viewed digital technology as information infrastructures (Hanseth et al., 1996) and also has conceptualized platforms, such as Facebook, as digital infrastructures (Tilson et al., 2010). However, this thesis adopts more recent platform conceptualizations (Tiwana, 2013; Yoo et al., 2012) and views mobile platforms as digital platforms.

Digital platform can be viewed as a modular structure and design in which modules are connected to each other through interfaces (Baldwin and Clark, 2000). These together form a platform architecture (Baldwin and Woodard, 2008) or also are conceptualized as a layered modular architecture (Yoo et al., 2010). Interfaces are central for the compatibility between the modules (Farrell and Saloner, 1992), but compatibility may also be achieved through use of converters (Farrell and Saloner, 1992) or gateways (Hanseth, 2001). In a platform architecture specifically, interfaces mediate between the platform core and its complements and are thus essential in controlling the platform and its openness (Baldwin and Woodard, 2008; Tiwana et al., 2010). For example, the application programming interface (API) defines how apps can be built on top of the core platform.

For digital platforms, openness is valuable for triggering generative code development and innovation (Yoo et al., 2012; Zittrain, 2006) and also elemental for scaling mechanism, by which a platform can reach new partners (Henfridsson and Bygstad, 2013). Conceptualized as open plat-

form strategy, Boudreau (2010) distinguishes two types of categorical approaches to openness: granting access to complementors and giving up control of the platform itself. The former refers to the opening of interfaces (as described in the previous paragraph) and the latter to open-sourcing a platform or its parts. Regarding open-sourcing, fully proprietary and fully open platforms are the two extreme strategies, but a hybrid strategy is also conceivable (West, 2003; Eisenmann et al., 2008). In a hybrid strategy, the firm is willing to open-source parts of the platform, i.e. forfeit its IPR, while regulating access to other parts to generate revenues (West, 2003; Barnett, 2011).

For digital platforms, APIs, open-source licenses, and other software tools and regulations are thus the concrete strategic means to organize open platform strategy, which Ghazawneh and Henfridsson (2013) conceptualize as boundary resources. One of the key strategic issues in open platform strategy is the balance between openness and control (Ghazawneh and Henfridsson, 2013; Eaton et al., 2015; West and O'Mahony, 2008). With openness, a platform owner can transfer design capabilities and attract contributions from third parties, while with control, it can secure and protect the compatibility of the platform (Ghazawneh and Henfridsson, 2013).

Boundary resources include several strategic controlling mechanism such as design and engineering decisions (Woodard and West, 2011), architectural IP (Boudreau, 2010), control of a standard (West and Dedrick, 2000), and control of the API (West and Dedrick, 2000; Ghazawneh and Henfridsson, 2013). Furthermore, boundary resources are not necessarily in the full control of the host and may also be tuned by complementors and other actors in the service network (Eaton et al., 2015). Moreover, several studies have indicated the importance of control of the boundary resource, such as APIs, over controlling the platform itself (Schilling, 2000; Baldwin et al., 2009; Pon et al., 2014).

Taken together, in this thesis, a mobile platform is viewed as *a digital platform,* having a modular design with interfaces in between the modules. Following Ghazawneh and Henfridsson (2013), interfaces, software tools, and regulations between the platform owner and complementors are termed as *boundary resources.* Following Boudreau (2010), strategy of increased openness of platform, either by open-sourcing platform's resources or by enabling cooperation with several types of complementors through open interfaces, is referred to as *open platform strategy.* Fur-

thermore, adopting the view of Yoo (2013), instead of seeing technology as an exogenous variable, technology's digital materiality is recognized (Orlikowski and Iacono, 2001), and thus digital technology is presumed to have by nature a central role in open platform strategizing.

2.3 Strategic threats for open platform

Opening up the platform for external contributions using boundary resources makes it at the same time vulnerable to exploitation. Previous management research has studied exploitation as free-riding (Albanese and Van Fleet, 1985). In the context of open-source software communities, research has identified how users download software but do not contribute (Hippel and Krogh, 2003) and how individual developers use the code themselves but do not give back to the community (Baldwin and Clark, 2006). Dahlander and Magnusson (2005) studied the relationships between open-source communities and the firms co-existing with them, and conceptualized less harmful activities as being commensalistic while those activities that are directly harmful to the platform owner are parasitic.

In a digital platform context, code forking is one threat. In general, forking refers to a situation when "there exist two independent software projects, deriving both from the same software source code base" (Robles and González-Barahona, 2012, p. 1). As a specific threat related to forking, Parker et al. (2009) note that incompatible forks may lead to the fragmentation of the platform.

In an alliance setting, Lavie (2006) identifies outbound spillover rent as a negative rent diminishing firms competitive advantage. More specifically, outbound spillover rent refers to leakage of resources of the focal firm when another party in the alliance opportunistically exploits them for its private benefit (Lavie, 2006).

As a concrete example of exploitative platform-forking activity in the mobile domain, Amazon forked the AOSP, cloned the APIs, and built its proprietary Fire platform on top of Android without contributing anything back. In a recent study, Pon et al. (2014) analyzed Amazon and noted that Amazon has been successful in leveraging existing complementors from the Android ecosystem and that specifically, in terms of business, Amazon now directly competes with Google.

The platform envelopment (Eisenmann et al., 2011) is a somewhat sim-

ilar strategy to platform forking, in which an attacker from another market bundles a platform in ways to leverage shared users and components of the targeted platform. However, in the platform envelopment, the target platform is either a complement, a weak substitute, or an unrelated platform (Eisenmann et al., 2011), whereas in platform forking the two platforms are strong substitutes.

Taken together, in this thesis, *strategic exploitation* refers to leakage of the focal platform's resources diminishing platform owner's competitive advantage. *Platform forking* is a specific form of exploitation in which not only software resources are forked and exploited but *platform fork* also creates a competing platform and a situation where value, such as complementor apps, can easily transfer to the fork from the host.

The synthesis of theoretical perspectives and key concepts for this thesis are summarized in Table 2.1 below. The first column lists the theoretical perspectives and concepts as seen in IS literature, the second column lists the corresponding concepts in platform and strategic management research, and third column presents the synthesis and chosen concept for the open platform context of this thesis.

Table 2.1. Synthesizing theoretical perspectives and concepts between IS and platform and strategic management research

	Information systems (IS) research	**Platform and strategic management research**	**Synthesis for open platform context**
Perspectives	Generative nature of digital technology (Yoo et al., 2010)	Modularity as a strategic approach (Baldwin and Clark, 2000)	Both to be leveraged
	Materiality of digital technology (Orlikowski and Iacono, 2001)	Technology as an exogenous variable (noted by Yoo, 2013)	Digital technology has by nature a central role in open platform strategizing
Concepts	Information infrastructure (Hanseth et al., 1996), Digital infrastructure (Tilson et al., 2010)	Technological platform, Industry platform (Gawer and Cusumano, 2002; Gawer, 2010)	Digital platform
	Layered modular architecture (Yoo et al., 2012), Platform architecture (Tiwana et al., 2010)	Modular design (Baldwin and Clark, 2000), Platform architecture (Baldwin and Woodard, 2008), Software stack (Gao and Iyer, 2006)	Platform stack
	Boundary resources (Ghazawneh and Henfridsson, 2013)	Interfaces (Farrell and Saloner, 1992; Baldwin and Clark, 2000)	Boundary resources
	"Ecosystem", Platform ecosystem (Tiwana et al., 2010)	Business ecosystem (Moore, 1993), Interfirm network (Uzzi, 1997), Platform ecosystem (Alstyne et al., 2016)	Platform ecosystem

3. Material and Methods

To answer the overall research question, "How can platform owners manage cooperative and competitive strategic interplay in the platform ecosystem?" the case study method (Yin, 2009; Eisenhardt, 1989) was chosen for the study. Case study is well suited for answering how type of research questions (Yin, 2009), and it naturally allows an iterative approach (Eisenhardt, 1989) that fits well in structuring research consisting of a series of several publications.

3.1 Scope of case study

For studying strategizing in the digital platform business, the mobile industry has emerged as the forerunner, and thus mobile platforms were selected as the subject of analysis for the study. Instead of the firm, platform was chosen as the unit of analysis for two reasons. In mobile business, platform is the digital artifact through which strategy is exercised, products are built around it, and thus it is in the center of competition and cooperation, the focus of this study. This choice also clarified the analysis for situations in which the firm owns and hosts simultaneously several platforms, such as how Nokia had Symbian and Windows Phone platforms, by providing a possibility to analyze each platform and the strategies related to them separately.

Figure 3.1 illustrates the coverage and scope of the case study in time and across mobile platforms. Each individual publication of this compilation thesis is illustrated with a dashed box in the figure and marked with the corresponding Roman numeral. As we can see from the illustration, the study covers the time from the beginning of smartphone era (introduction of Symbian platform in 2006) up until recent developments of the Android platform in 2015. Platform wise, the study covers all major plat-

forms, including both firm and community-oriented platforms, as well as successful and failed ones. From the geographical perspective, the case study covered firms from all major markets including US, Europe, and China. The only notable platform missing is Blackberry OS by Research in Motion. The reason for omitting Blackberry was due to timing and resource constraints. At the time of the second study, Blackberry wasn't among the top three platforms, and as the third study was a continuation of the second and the fourth focused on the Android-based forked platforms only, it was excluded from these studies as well. Furthermore, due to resource constraints, since the study already included the two leading US-originated platforms, it was possible for Blackberry to be omitted.
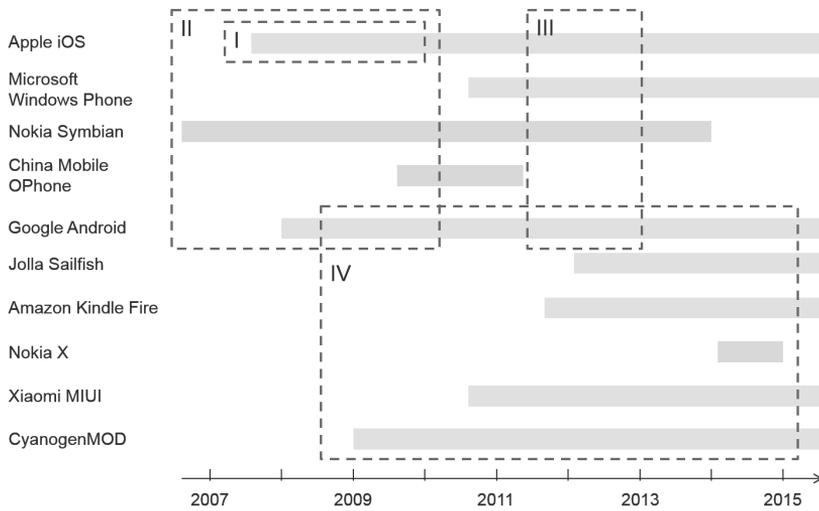
Figure 3.1. Coverage of each case study in time dimension and across mobile platforms

3.2 Materials

This case study relied on following sources of evidence: document and archival sources in the Web, expert survey, executive opinion poll, and executive interviews. The materials used for the study are summarized in Table 3.1.

Web-based materials can be argued to be rich and accurate sources for studying digital business that by nature is largely exercised openly and online on the Web. This approach is in line with recent urging for strategy research to take online strategizing seriously (Vesa and Vaara, 2014). Moreover, Web-based data has been used as the sole source in several re-

Table 3.1. Materials used for the study

Source of evidence	Amount	Article that utilized
Web-based material	Approx. 300 documents (incl. tech news, reports, blogs, legal docs, see above for details)	I, II, IV
Expert survey	4 academics, 2 analysts, 2 telco managers	III
Executive opinion poll	5 platform executives	IV (Rev.), Summary
Executive interview	2 platform executives	IV (Rev.), Summary

cent strategy and IS related studies (for example, see Eaton et al., 2015; Ghazawneh and Henfridsson, 2013). The Web-based evidence collected for this study included: technology news, websites of case companies (technical information, company data, and executive blogs), archival sources such as reports on mobile platforms, and the legal documents (such as terms and conditions and OS licenses).

In addition to using Web-based materials, the study utilized data from an expert survey, executive opinion poll, and executive interviews. A two-round Delphi survey was conducted among experts from academia and industry to assess competition and cooperation levels of each mobile platform (III). Furthermore, as part of revising Publication IV for a journal, an expert opinion poll was conducted and two executives in charge of technology and/or research among the case firms were interviewed and the data were utilized also in revising the findings for this dissertation synthesis.

3.3 Research process

The case study was organized as an explorative and inductive multiple-case study, in which each publication extended and deepened the analysis of previous publications. Each study was a multiple-case study, and as a whole they formed a large multiple-case study of the mobile industry. In each individual study, a similar methodological approach was used. First, an initial theoretical proposition was developed for the study. Second, data were collected for each case individually based on the proposition.

Third, cases were compared against each other and conclusions from the cross-case analysis were used to update the theoretical model. Following this, the next iteration, i.e. follow-up case study, continued from the updated model by extending the study to new cases and/or complementing a new dimension to the theoretical analysis. Finally, this compilation thesis collects and synthesizes the results from the four iterative case studies.

In deriving the results and contributions, the research process employed in this thesis adopts perspectives from the critical realist view for case study research (Easton, 2010). In critical realist perspective, identifying structures and events are central to study a phenomena and its related mechanisms, such as platform forking. For this purpose, this thesis utilized detailed descriptions of the case platforms available online to understand the structured entities such as platform stack and boundary resources attached to them. Furthermore, to collect the events caused by the underlying mechanisms, case platform histories were analyzed and triangulated from various sources (incl. blogs, news, histories). Finally, through cross-case analysis, the common mechanisms were revealed and reflected against existing literature to derive the contributions of this study.

4. Results

In this chapter the results of this dissertation are presented by answering each research sub-question in a separate section. First, Section 4.1 develops a conceptual model revealing the key actors of an ecosystem built around mobile platforms (I, II, III). Section 4.2 then opens up the digital platform stack and the strategic role of boundary resources in enabling value creation between the platform owner and other actors in the platform ecosystem (IV).

After presenting the conceptual model, Section 4.3 uses the model to analyze the cooperative and competitive strategizing *within* a digital business ecosystem by comparing four mobile platform ecosystems head to head (II, III). More specifically, this section presents a quantitative network analysis revealing platforms' levels of cooperation and competition towards other actors in their ecosystem (III).

After analyzing competitive and cooperative dynamics within an ecosystem, Section 4.4 moves to analyze competition *between* platforms by showing how cooperative approach may lead to exploitation by competing platforms and how platform owner can protect and defend against it (IV). Finally, Section 4.5, the summary of results, presents how each research question was answered by the study.

4.1 Key actors of the platform ecosystem

Before proceeding to actual analysis of cooperative and competitive strategizing in a platform ecosystem, a conceptual model is needed to understand who the key actors representing the various strategic activities in the ecosystem are and between whom the cooperation and competition is realized. The research question for this section is: Who are the key actors in a platform ecosystem around mobile platform? The question is

answered by summarizing the findings originating mainly from Publication I but including refinements from the follow-up case studies II and III.

Abstracted actor approach

The approach of this study is based on the idea of using abstracted actors instead of real companies (III). Traditionally, competition and cooperation is viewed as a relationship between two concrete firms. However, in an ecosystemic setting, one can take a more abstract perspective and see firms as having a certain role. For example, HTC, a concrete firm, has the role of device manufacturer in Google's Android ecosystem. On the other hand, Google is the platform owner controlling and organizing the platform ecosystem. Furthermore, Google can also be seen taking other roles such as the device manufacturer role as it produces and sells Nexus devices together with its partners.

By seeing firms as representatives of this type of roles, i.e. abstracted actors of the ecosystem, one can analyze the competitive and cooperative stance in a more pure and strategic sense (III). Strategy "is the creation of a unique and valuable position, involving a different set of activities" (Mariana Mazzucato, 2002, p. 18). Having an abstracted actor representing each significant activity in the platform ecosystem, one can evaluate the platform owner's competitive and cooperative stance towards each of these actors and thus reveal the overall strategic positioning regarding the key activities.

More specifically, the abstracted actor approach both makes it possible for one firm to have several roles in a strategic sense (e.g., Google example above) and doesn't unnecessarily differentiate the relationship towards distinct firms that from the platform owner perspective have the same strategic role in the ecosystem. These aspects will be further analyzed in the forthcoming Section 4.2.

Conceptual model of mobile platform ecosystem

To reveal the key actors, a conceptual model was developed for mobile platform ecosystem containing all key actors and interactions between them. The initial conceptual model for this study was developed from two cases: the ecosystem around Apple's iOS platform and the ecosystem around bioinformatic marketplace called BioCatalogue (I). Model was

then refined specifically for the mobile industry in two subsequent case studies (II, III) that both analyzed various mobile platforms. Figure 4.1 presents the final model for a platform ecosystem around a mobile platform. The model has been slightly refined and synthesized from the publications to contain all the necessary elements required by the forthcoming analyses of competition and cooperation in various platform ecosystems. Next, elements in the model are briefly explained.
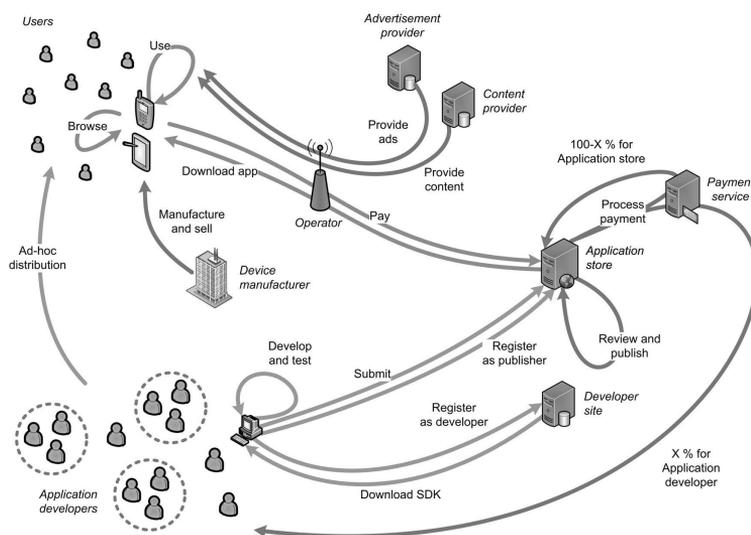
Figure 4.1. Conceptual model of a mobile platform ecosystem (adapted from III)

The underlying idea of the model is that it models all the activities between user, developer, the various roles of the platform owner, and third-party firms required for the user to be able to use a mobile app (for details of the use-case modeling approach, see Publications I and II). This way, all the key actors of the ecosystem can be revealed. The model is built around a central role, the application store, located in the middle on the right side of the figure. Application store serves as the mediating actor between developers and users, the two critical sides of the multi-sided platform. The lower part of the figure then illustrates the developer activity (green) in which the developer develops and publishes a new app. Correspondingly, the upper part represents the user activity (red), in which the user finds, downloads, and buys an app. The blue lines illustrate the interlinking parts that are controlled by other actors. These include device manufacturer, advertisement provider, content provider, payment service, and developer site. Each actor is represented by its own symbol in the figure.

4.2   Strategic digital elements of open platform

The previous section revealed the key actors of a mobile platform ecosystem. These actors are all critical for platform owners to build a thriving ecosystem. The purpose of this chapter is to dig deeper and analyze the platform artifact through which the platform owner manages and organizes these actors and thus the ecosystem overall. The research question for this section is: What are the main digital elements of a mobile platform and their strategic design purposes? The question is answered by summarizing the findings mainly from Publication IV with some supportive early findings from Publication I.

Platform Stack

The starting point for the analysis is to view platform as a modular structure and design in which modules are connected to each other through interfaces (Baldwin and Clark, 2000). Modular architectures, also called software stacks, have been analyzed earlier, and also specifically for mobile platforms (for example, see Tarkoma and Lagerspetz, 2011). However, there is no agreed-upon generic representation available for a mobile platform that could have been used as a basis for this study. For this purpose, several representations were synthesized from both academic articles (Gao and Iyer, 2006; Yoo et al., 2010; Tarkoma and Lagerspetz, 2011) and from Web resources, including developer communities and official platform websites, to form a model of generic stack for a mobile platform (IV). The resulting complete stack, called the platform stack, is represented in Figure 4.2.
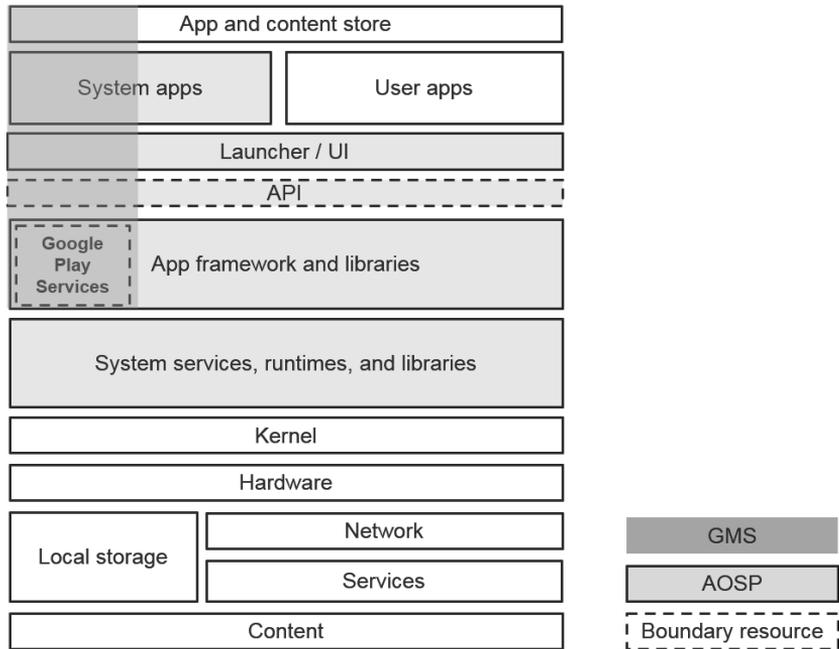
Figure 4.2. Generic platform stack of mobile platform (adapted from IV)

As the figure illustrates, mobile platform is an example of a digital product platform (Yoo et al., 2010) encompassing a core platform to which complementors can add resources such as apps. Contrary to Yoo et al. (2010) and Gao and Iyer (2006), network, service and content layers are placed at the bottom of the stack. This provides a consistent stack of layers illustrating the execution flow from an app (either a system or a user app, collected into an app and content store) opened from a launcher, proceeding through the API and app framework, system services, kernel, hardware, and finally reaching content either locally in the device or in the cloud through the network and service layers.

In line with a modular design view of Baldwin and Clark (2000), all platform stack elements, including the boundary resources, are modules that together make up the complete design and structure of the platform. It is important to recognize here that specifically APIs between the modules are also viewed as a module. As we shall see later in Section 4.4, APIs as modules have a central role in producing alternative designs of the platform through platform forking.

In addition to layers and modules generic for all mobile platforms, Figure 4.2 also has some specific Android components overlaid: Google Mobile Services (GMS), the proprietary Google apps, in dark grey; Google Play Services; and Android Open-Source Platform (AOSP) in light grey.

These are further elaborated in the forthcoming Android specific analysis of Publication IV.

Boundary resources and their cooperative design purposes

To foster and support value co-creation in the platform ecosystem, there are several essential digital artifacts and elements that platform owners need to take care of. For example, it is important that there are some standards, APIs, and SDKs that make re-using, combining, and interfacing with platform and other services easier. There must be mechanisms and tools, such as open-source licenses and a collaborative development environment, for sharing and collaborating with developers. Furthermore, to co-create business with app developers, there needs to be tools to manage distribution and selling of apps, namely payment service and app store. (I)

In the recent IS literature, these software tools and regulations have been conceptualized as boundary resources (Ghazawneh and Henfridsson, 2013; Eaton et al., 2015). According to this stream of research, the main strategic purposes of boundary resources are fostering app creation (resourcing) and controlling and securing the compatibility of the platform (securing).

Based on the analysis of Android platform carried out in Publication IV, a richer picture emerged, with boundary resources having a multitude of strategic design purposes. Altogether, 10 boundary resources were identified and classified under three broad strategic design purposes essential to the platform business: contribution leverage and control, securing compatibility, and distribution and value appropriation (for a full list and details, see IV).

Contribution leverage and control refer to the resourcing and controlling of the complementors using boundary resources such as API, SDK, and open-source licenses. Securing compatibility refers to activities to ensure the compatibility between the core platform and complements built on top of it. For example, Google Android has a compatibility definition document and test suite (CDD&CTS) boundary resources that device manufacturers have to pass before Google services such as Google Maps and Google Play can be licensed for the device. With similar purpose, the alliance membership agreement boundary resource ensures that alliance members work towards a unified and compatible ecosystem.

Distribution and value appropriation refers on how digital goods, e.g.

apps and data, are distributed in the platform ecosystem and how different actors can appropriate value from them. Examples include app and content store, packaging definitions, and client library. For example, the app and content store, such as Google Play in the case of Android, is a critical technical boundary resource providing a distribution and monetization channel for app and content complementors, and naturally it is an important revenue source for the host as well.

Google Play Services is an example of client library boundary resource identified from the Google Android case. The goal of this system app is to address Android's version fragmentation problem by enabling more frequent Google service updates that are independent from operating systems releases (Pon et al., 2014). Accordingly, as a boundary resource, the purpose of a client library is to distribute APIs and service updates not only between the platform and developer but also between these two and the end users. Furthermore, because Google Play Services wraps the APIs, it is also a critical boundary resource for Google's value appropriation from the user side. This is because user data, powering Google's search and ad business, flows through the APIs.

Competitive perspective to boundary resources

Apart from having the above-listed positive strategic design purposes to attract and foster cooperation, boundary resources have a negative side that has been largely neglected in the existing literature (e.g., see West and Bogers, 2014).

According to this study, open boundary resources are also weak points through which external actors can exploit the platform without contributing anything in return (IV). For example, Amazon exploits Android's resources to build its competing Fire platform through the use of several boundary resources. Amazon has forked the AOSP using the open-source license boundary resource and cloned the APIs to provide app compatibility. However, in a similar manner to the ability to use boundary resources to control the complementors, platform owner can also use them to defend against exploiters (IV). The strategic exploitation dimension and resulting strategic interplay is further analyzed and explored in Section 4.4.

Extended boundary resources model

To conclude the findings presented in this section, the original boundary resource concept (Ghazawneh and Henfridsson, 2013) can be extended and clarified in three aspects. First, the concept can be extended to cover not only developers but any other complementor of a multi-sided platform. For example, Android uses the CDD&CTS type of boundary resources to control device manufacturers. Second, using the platform stack, boundary resources can be accurately located by connecting them to the specific stack elements. For example, API is located specifically in between app- and app framework and libraries layers. Third, the concept can be extended to also cover exploitation; the boundary resources that are designed to enable external contributions may also enable non-designed exploitation of the resources of the platform owner. Finally, the platform owner can use boundary resources to control and defend against exploiters. The resulting conceptual model of boundary resources is illustrated in Figure 4.3.
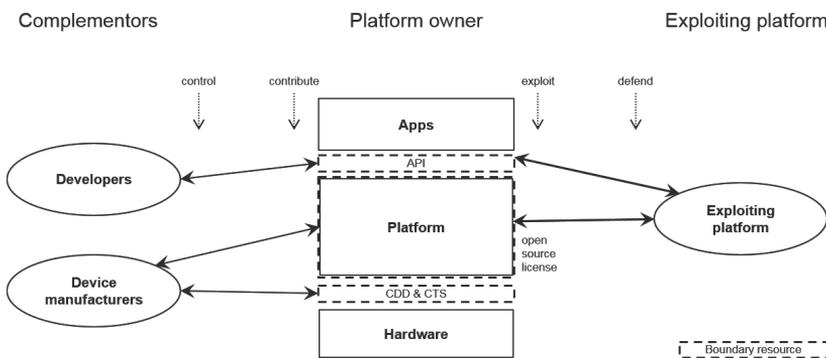
Figure 4.3. Conceptual model of boundary resource (adapted from IV)

4.3 Managing cooperation and competition within a platform ecosystem

Previous sections have built a conceptual model of key actors in the platform ecosystem and identified the digital elements, platform stack and boundary resources, through which cooperation and competition between actors is realized. The purpose of this section is to move from structural analysis to analyze cooperative and competitive strategizing within each platform ecosystem. The research question for this section is: How do

mobile platform owners cooperate and compete with other actors in their platform ecosystem? The question is answered by summarizing findings from Publication III, which was a follow-up study for similar comparison in Publication II.

Modular approach to cooperation and competition in platform ecosystem

Previous sections have built a conceptual model of a platform ecosystem in which complementor firms cooperate with the platform owner by using boundary resources to complement modules such as apps on top of the platform. In other words, the modular platform stack and boundary resources attached to the modules are the artifacts through which cooperation is realized. Thus, a platform owner can be viewed as cooperating with an actor if the owner allows that actor to produce complements within its platform.

In a multi-sided platform, there are typically several competing firms offering the same complements, i.e., same modules, to the platform. Thus, competition can be viewed concretely as competition for a market share of a specific module of the platform stack. Furthermore, the platform owner can decide to compete for the same module that it has also opened for complementors for cooperating with them. Combining cooperation and competition simultaneously, platform owner can be viewed as having a coopetitive strategy (Bengtsson and Kock, 2000). For example, Google produces and sells Nexus devices and thus also simultaneously competes with its core collaborators, the device manufacturers. Following from this, coopetition can also be defined as simultaneous cooperation and competition towards an actor producing a specific platform stack module.

To analyze overall cooperation and competition in a platform ecosystem, in addition to a modularized view of cooperation and competition towards specific actors, one needs a measure of the strength and a way of modeling them. For this study, an expert survey using Delphi method was conducted to assess strengths of cooperation and competition with each actor (III). Survey consisted of separate assessments for cooperation and competition with each actor using a 5-point Likert scale assessment. Furthermore, for comparative analysis, each assessment was conducted separately for each platform. The reasoning behind the modular approach is that to reach a truer assessment of a platform's overall levels of cooperation and competition, assessment shall be first done on a module level,

where competition has a concrete meaning (e.g. competition for a specific module, such as device) and only after that summarize values to the platform level. To clarify, platform level refers here to the summarized competitive and cooperative stance of the platform owner towards other actors in its platform ecosystem, and not the competitive or cooperative stance towards other platforms.

To capture dynamics in the cooperative and competitive strategic interplay, in addition to assessing a current strategic stance, some questions in the survey involved assessment of change in the strategy. These involved both historical changes (before-now) and anticipated future changes (now-after). For an example of a historical change, experts were asked to assess the change in Apple's policy to allow developers to use third-party advertisement service providers in addition to Apple's own advertisement network. For an example of an anticipated future change, experts were asked to assess a situation in which Google has completed the acquisition of Motorola (at the time of survey acquisition was not yet confirmed) and thus in effect became a major device manufacturer.

As a first step in the analysis, assessments from multiple respondents were first aggregated into single value using response-data-based weighted mean (Bruggen et al., 2002). This aggregation produced averaged assessments of module-level cooperation and competition with each actor separately for each platform. In the next step, to illustrate the differences between platforms, platform-level cooperation and competition values were produced from module-level values by calculating centrality degree for the competition and cooperation networks formed for each platform between the owner and other actors. Traditionally, edges in the networks are assumed to be binary (i.e., there either is an edge or there is not). Recently, Newman (2004) presented that classical centrality degree (Freeman, 1978) can also be applied to weighted networks in a straightforward manner by interpreting weight as multiple edges. Following from this, in this study, aggregated assessments were used as weights in the competition and cooperation networks and Newman's approach was used to calculate degree centrality in these weighted networks (for details, see III).

Increased competition against own complementors results in coopetitive strategy

The main result of the analysis conducted in Publication III, the platform-level aggregate values of both cooperation and competition for each platform, is illustrated in Figure 4.4. Similarly to Lado et al. (1997), competitive and cooperative orientations are separated into their own axes. Horizontal axis represents platform owner's overall cooperation towards other actors in its platform ecosystem. The higher the value in this dimension the more cooperative possibilities, i.e. more modules opened for complementors, the platform owner provides. Vertical axis represents the platform owner's overall competition with other actors in its ecosystem. The higher the value in this dimension the more the platform owner competes, i.e. the more modules it sells and produces itself, against other actors. The effects of strategic changes due to before-now or now-after events are illustrated using arrows.

Next, the strategic stance and developments of each platform will be briefly explained and compared. Please note that this part of the analysis originally involved years 2011-2013. However, in the following analysis, recent developments also will be commented upon when deemed relevant.
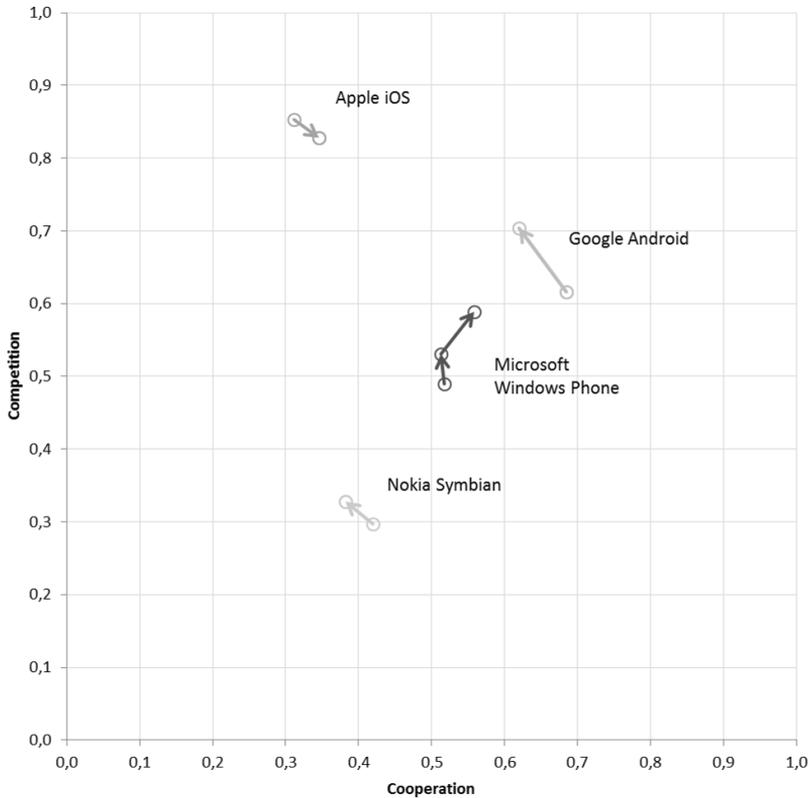
Figure 4.4. Comparison of mobile platforms in competition and cooperation dimensions (adapted from III)

As we can see from the figure, based on the experts' assessments, Apple has chosen a different strategy from the others by being the most competitive and the least cooperative. Contrary to Apple, Google is the most cooperative but has a significant level of competition as well. We can also see that Google's acquisition of Motorola moved it significantly toward Apple's strategic position. Overall, we can say that Apple's platform strategy is closer to a traditional competitive strategy (top-left corner), whereas Google's strategy is closer to the lately emerged coopetitive style (top-right corner), in which a company chooses also to cooperate with its competitors. Microsoft, the newcomer in the business at the time of analysis, entered the market balancing somewhere between Google and Apple. Acquisition of Skype (first arrow) and getting into the tablet business (second arrow) moved Microsoft closer to Google's strategy. At the time of analysis, Nokia Symbian was already a dying ecosystem; consequently, experts probably assessed both competition and cooperation levels as quite low. It seems that Nokia's dramatic loss in market share affected experts' assessment,

and thus Nokia's position in the graph is questionable.

Since the time of the study, we have seen some significant developments in mobile industry. Google sold Motorola Mobility to Lenovo, and Nokia sold its phone business to Microsoft which in turn essentially put smartphone development on hold lately and sold its feature phone business to Foxconn and HMD global. These changes are not reflected in the figure. Taking them into account, Google would probably be assessed as less competitive and Microsoft and Nokia can more or less be removed from the figure for the time being.

Overall, it seems that the three platforms are converging to use a similar restricted coopetitive oriented strategy, in which they operate themselves in several business areas and at the same time offer selected business opportunities for complementors (top-center area in Fig. 5). From complementor perspective, this can be an unhealthy situation in which the platform owner competes against you. In a way, a true ecosystemic approach is on the bottom-right corner. In this corner, platform firm can be viewed as focusing on governance and doing less business on individual platform stack modules and instead letting others do business in these sectors. Recently, there have been some developments and efforts in the mobile domain in this kind of a more ecosystemic direction. Some examples are: HTML5 web apps standard, Mozilla's Firefox OS platform, and Microsoft's recent efforts to develop tools that help developers to port their existing iOS and Android apps to the Windows 10 platform. However, so far none of these have been hugely successful in mobile domain.

4.4   Strategic exploitation in open platform ecosystem

In contrast to the previous section that explored competition and cooperation inside each platform ecosystem, in this section, analysis is moved to study strategizing between competing platform ecosystems. The research question for this section is: How do mobile platform owners manage cooperative and competitive strategizing towards other platform firms? The question is answered by summarizing the results from Publication IV that studied the Google Android open digital platform and five platform forks that set out to strategically exploit the Android.

Platform forking through open boundary resources

Despite the positive leverage effects from attracting complementors, there are also strategic threats to being too open. The openness of digital platforms also attracts external players who use boundary resources to exploit the platform without contributing anything in return or by adding value to the platform ecosystem. Boundary resources that are too open are in a way weak points or wounds in the platform through which a competing platform can potentially attack and exploit resources.

A specific strategic form of exploitation is platform forking. In software development, forking refers to when a software project bases its source code on another project, i.e., forks the source code development, and modifies and builds enhancements on top of it (Robles and González-Barahona, 2012). In this study, it was found out that a platform fork not only exploits the software resources of an open platform but also creates a competing platform and a situation where value, such as complementor apps, can easily transfer to the fork from the host. As an example, both Amazon has forked the AOSP and built its own Fire platform competing with the official Google Android. (IV)

The way platform forks bundle the competing platform can be viewed as generating an alternative modular design of the platform (Baldwin and Clark, 2000). Baldwin and Clark (2000) identify six generic modular operators—splitting, substituting, augmenting, excluding, inverting, and porting—that can be operated on the individual modules or groups of modules to produce alternative designs. Furthermore, these six operators together "applied at various points and in different combinations, can generate all possible evolutionary paths for the structure" (Baldwin and Clark, 2000, p. 123). As an example of using modular operator, Amazon can be viewed as substituting proprietary Google Maps module with a mapping services licensed from Nokia Here.

In the analysis of Publication IV, similarly to modular operators, it was found out that platform forks used a set of basic approaches towards boundary resources and the other modules they control when they exploited alternative forked designs of the platform. Analysis revealed three specific operators, called here forking operators, that were used as part of bundling the forked platform: branching, cloning, and hacking. It is important to note here, that the Baldwin and Clark's parsimonous set of modular operators are justified by their capability of producing novel de-

signs, whereas the forking operators, while also operating on modules and when orchestrated together resulting in a new design, are motivated by their capability of forking the host platform or business built on top of it.

Branching is a forking operator in which the exploiting platform uses the host platform's open-source license to branch the source code module governed by it and then modify the code branch according to its specific needs. Branching differs from substituting in that it has the idea that the existing module is exploited as much as possible even though the resulting modified module can be viewed as a substitute.

Cloning is a forking operator in which the exploiting platform copies the original module exactly to ensure compatibility with the original platform. Cloning doesn't make any sense as a generic modular operator, since it doesn't produce any new design, but it is a purposeful and critical forking operator for enabling compatibility of the complements for the forked platform as will be illustrated in the forthcoming Amazon example.

Hacking is a forking operator in which the original module is hacked to also work with the exploiting platform. Again, hacking doesn't produce any new design, but sometimes a specific module required for the platform or critical for business is not readily available and platform fork may need to use some unintended means to get the module into its platform.

The generic modular operators and forking operators were combined in several ways by the platform forks to bundle resources into the platform stack (for comparison and details, see Table 1 in IV). To illustrate how platform forking is realized, the earlier presented platform stack (Figure 4.2) and boundary resources models (Figure 4.3) need to be integrated together with the modular and forking operators. Synthesis of these models is presented in Figure 4.5 through a concrete example, illustrating how Amazon has bundled the Fire platform by exploiting Google Android.

Figure 4.5 shows a combination of modular and forking operators (black arrows) that Amazon exercised on specific boundary resources and other modules that they control in Google Android. Most significantly, Amazon has *branched* the platform core, i.e., the AOSP, which Google has published using the Apache OS license boundary resource, and thus obtained the core platform for free. In relation to AOSP, both Google and Amazon have *ported* kernel from the Linux kernel open-source project. Amazon has *substituted* Google Play (app and content store boundary resources) and other proprietary modules of Google Android (included in the GMS). In order to help Android's developer complementors to also multi-

home, i.e., re-submit their apps into Fire platform, Amazon has *cloned* the Google APIs. As part of the bundling of the complete platform stack, Amazon has also substituted hardware and content layers with its own offering.
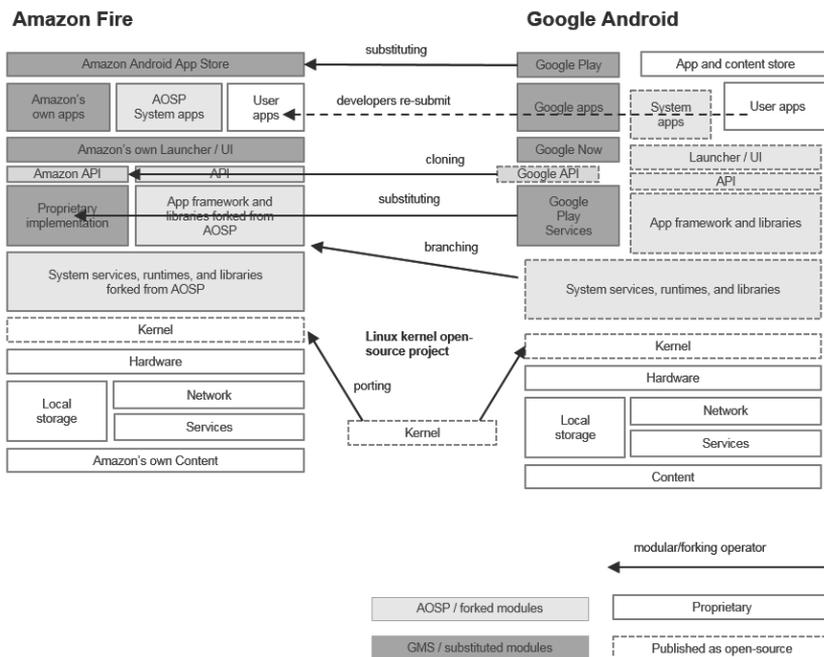
Figure 4.5. Bundling of Amazon Fire platform by combining modular and forking operators (adapted from IV)

Strategic responses by the host to the exploitation

The previous section revealed how exploiting platforms purposefully use various forking operators toward boundary resources to exploit resources from an open platform. This section presents analysis and findings of Publication IV regarding the host's, i.e., Google's, responses to exploitative actions by the platform forks (for details, see Table 3 in IV). Analysis reveals novel insights into how boundary resources also are used defensively in open platform settings resulting in a strategic interplay between the host and the exploiter.

Analysis of Google's responses reveals that boundary resources are active tools and central resources for defending against exploiting platforms and blocking the leakage of platform resources. Five strategic responses were identified in which boundary resources were either central resources to be defended or the concrete strategic tools used in defense by the host.

The qualitative characterization of the strategic nature of each event is based on our analysis and interpretation of the data used in this study, while the timing and technical details of the events are factual.

First, in response to the CyanogenMOD developer community hacking the Android Market (now Google Play) into its forked version of the platform, Google defended the app and content store boundary resource by threatening with legal action. Second, after the first commercial platform forked from the AOSP, Xiaomi, was announced, Google utilized the possibility of Apache open-source license boundary resource to close up further development of the critical parts of earlier open-sourced modules of its platform. Third, when OHA member Acer tried to launch a forked Aliyun phone in partnership with Alibaba, Google employed the alliance membership contract boundary resource to bring Acer back in line and forced it to cancel the launch.

In connection to the platform forking by Amazon (as presented in Figure 4.5), there were two more defensive moves. First, when Amazon launched the Fire platform with a strong substitute for app and content store module, Google claimed its ownership of the app and content store boundary resource by re-branding it from generic Android Market to Google Play and by strengthening its role and market position against Amazon's offering by adding music and bookstore to it. Second, when Amazon cloned the Google Maps API, Google defended this action by introducing a new client library boundary resource, wrapping the APIs to strengthen their control and to protect against copycats.

Furthermore, our analysis revealed that in three of the five responses, the matching exploiting activities by forked platforms had direct connections to the boundary resource used in the response. For example, when Xiaomi exploited the open-source boundary resource, Google reacted by using the same boundary resource to move development into a closed source. Similarly, when Amazon threatened Android's app and content store business, Google increased its control of the same boundary resource. Finally, when Amazon cloned the API boundary resource, Google increased its control of this boundary resource by wrapping it inside a new client library boundary resource.

Moreover, a temporal analysis of the entire Android history hints at an evolutionary development. In the early phase, Google reacted publicly and angrily, even toward the CyanogenMOD open-source community. Over time, instead of public outcries or legal claims, it has increasingly

utilized software technological, i.e., digital boundary resources, such as Google Play Services, in its reactions.

4.5 Results summary

To answer the overall research question of "How can platform owners manage cooperative and competitive strategic interplay in the platform ecosystem?", this thesis has presented results from Publications I-IV that together answer the four research sub-questions set forth in the Research objectives section. The main findings to each research sub-questions are summarized in Table 4.1.

These findings together answer the overall research question of this thesis by exposing the role of boundary resources as a central strategic tool to manage cooperative strategizing towards a multitude of complementors, in enabling competing platforms to exploit resources through platform forking, and for host to use them in defense. Boundary resources are thus elementary in managing strategic interplay both in the sense of combining cooperation and competition and in their enduring role in strategizing over time between the host and the fork. Each of these aspects and their scientific and managerial implications will be discussed in detail next in the Discussion section.

Research question	Main finding(s)
RQ1: Who are the key actors in a platform ecosystem around a mobile platform?	Conceptual model of mobile platform ecosystem (Figure 4.1)
RQ2: What are the main digital elements of a mobile platform and their strategic design purposes?	Comprehensive model of platform stack (Figure 4.2) and extended boundary resources model (Figure 4.3) with strategic design purposes exposed
RQ3: How do mobile platform owners cooperate and compete with other actors in their platform ecosystem?	Platform owners use increasingly coopetitive strategies combining cooperative open platform approach with simultaneous competition with their own complementors (Figure 4.4)
RQ4: How do mobile platform owners manage cooperative and competitive strategizing toward other platform firms?	Platform forks orchestrate forking operators to exploit open platforms through their boundary resources (Figure 4.5), and the host in turn uses boundary resources to defend

Table 4.1. Summary of main findings for each research question

Reflection on developing and synthesizing the results for this thesis from the individual articles

To help analyzing and comprehending the results of this thesis, this section provides a reflection on how the results have been developed and synthesized from the individual articles included in this study. Instead of four individual articles each exploring solely a specific angle, this research was more an iterative approach where each article developed thinking and reasoning further and guided the research towards the main contributions exposed and crystallized by the last article. In the following reflection, this development of thinking will be reflected by a critical examination of the first three articles.

The overarching theme of this dissertation is how to manage cooperative and competitive strategizing in open platform ecosystems. The first three articles had a more of an ecosystemic perspective focusing on comparing the leading mobile ecosystems whereas the last article focused on platform strategizing and detailed structures, events and strategizing around the Android open platform and the forked platforms exploiting it. On the other hand, the first three articles can be viewed as focusing on competitive and cooperative dynamics *within* a specific platform ecosystem whereas the last article extended the view on competitive strategizing *between* competing platforms.

The main contribution of the first article was to develop a conceptual model of a digital ecosystem (such as an ecosystem around mobile platform) exposing all the actors and interactions between them. At the early stage of research, the scope and perspective was quite wide and thus also bioinformatics was included as one of the cases to be studied. Since then, focus has been solely on mobile platforms. However, having two very different domains at the early stage helped to build a generic enough model that has throughout the research proven to be very useful in structuring the thinking and analysis. First article also directed to think about the digital elements enabling the value co-creation in the platform ecosystem and in part helped in the last article to expose the rich and strategic role of boundary resources in open platform strategizing.

The second article, despite being a shorter conference article, kicked off three important streams of analysis for the research. First, the article develops an early version of the comparative analysis, in which all mobile ecosystems are compared head to head based on their strategic choices

regarding openness and control of the platforms. Second, this article extended the research to China by including China Mobile's OPhone (not in production anymore) as one of the cases. Since then, extension to China has proven to be very relevant as one of the strongest platform forks, Xiaomi, analyzed in the last article, also originates from China. Third, this article provides commentary on competitive and cooperative challenges based on Moore's (1993) business ecosystem thinking and in part led to include coopetitive thinking into the research (analyzed in more detail in the third article) and development of managerial implications in the last article.

The third article develops a quantitative perspective in analyzing competive and cooperative dynamics in platform ecosystems. This article both helped to be more specific about competition, cooperation, and of their simultaneous combination, coopetition, but also brought the temporal aspect into the research by analyzing dynamics related to specific strategic changes in the case platforms. Last article continued with this approach by analyzing the strategic interplay in the Android ecosystem between 2007 and 2015.

Due to very focused analysis approach some of the assessments and results of the third article can be criticized and are worth elaborating here. Firstly, due to their completely different business models and monetization strategies, one can argue that Apple and Google cannot be compared based on cooperative and competitive aspects only. For example, due to Apple choosing a vertically integrated model and making most of the money from selling the phones, it cannot have a cooperative dimension similar to Google. Monetization strategy is certainly relevant for economic or business model analysis. However, the purpose of the third article was to illustrate the overall competitive and cooperative stance of each platform, and that is served well by the chosen approach. Secondly, seemingly cooperative actor can be very competitive in reality and vice versa. For example, in principle, Google has very cooperative image but as the analysis in the fourth article shows Google can also be very offensive towards its own complementors. Furthermore, similarly as Nokia was accused of squeezing the subcontractors, we cannot know how much Google squeezes its collaborators behind the curtain. Vice versa, Apple has a competitive image but is at the same time very cooperative towards its main complementors, developers. Overall, these comments prompt for more in-depth research on the nature and boundaries of competition and

cooperation in digital platform business.

Finally, a specific event analyzed in the third article, Google's acquisition of Motorola, is worth a comment. At the time of analysis, Google's intentions were not clear. In the framework chosen for the article, acquisition fitted the idea of Google increasingly operating on device business and thus becoming more competitive towards its hardware complementors. However, as it has turned out, Google later sold the manufacturing part of Motorola and kept the patents itself. In retrospective, it can be assumed that this was Google's intention in the first place, but nevertheless, acquisition was also a temporary move towards more competitive stance in the platform ecosystem.

5. Discussion

In this section, results of this thesis are discussed against existing literature and key contributions are identified. Furthermore, results are reflected from an industry perspective to reveal managerial implications. Finally, validity, limitations, and potential future avenues for research are discussed.

5.1 Contributions

This thesis makes three contributions. First, open platform ecosystems are depicted as a new kind of competitive environment with new competition forms and strategic challenges. Second, boundary resources are enriched to be the central strategic tools that are actively used to manage the strategic interplay with multitude of actors in open platform ecosystems, including cooperation with complementors, but also competition between the host and exploiting platforms. Third, boundary resources are thus theorized to have a central role in building and sustaining competitive advantage in open platform ecosystem. Each of these contributions are next discussed in more detail.

Characterizing and modeling competitive environment for open platforms

The traditional view of competitive environment centers around firms competing at arm's length in the marketplace using differentiated products to seek greater market share. Considering the open platform context, this thesis illustrates more intrusive forms of competition that move from arm's length to close range.

First, the combination of platform owner's open and cooperative strategy to attract complementors with the simultaneous vertical control of

the platform stack (i.e., operating also itself in various layers) leads to a situation in which third-party complementors face competition from the platform owner itself. Gawer and Henderson (2007) refer to this same phenomena and dilemma as "squeezing" (either price-wise or through the boundary resources) in their case study of Intel. While their focus is on organizational challenges faced by the platform owner, the point here is to illustrate the intrusive nature of competition directed toward own complementors by the platform owner that results from the asymmetric power relationship between the two.

A second example of an intrusive form of competition is platform forking, in which two platforms technically share common platform stack elements and simultaneously represent competing businesses. This leads to a situation in which the host platform faces competition from exploiting forked platforms. In this form of competition, it is instead the platform owner who faces the intrusive competition coming from the "kindred" platform forked from it.

Platform forking is a completely new type of strategic challenge for an open platform host. In platform forking, a competing platform uses a combination of forking operators to exploit modules of the open platform to fork both digital resources and business built on top of the platform. At the same time, platform forking is an opportunistic strategy for a newcomer to enter the platform business. In contrast to platform envelopment, in which the target platform is either a complement, a weak substitute, or an unrelated platform (Eisenmann et al., 2011), in platform forking the two platforms are strong substitutes.

Furthermore, platform forking is highly competitive causing value leakage of complements and user data from the open platform host to the fork. While from the innovation perspective platform forking can be considered as having positive impacts for consumers and the industry as a whole (new improved characteristics), from the host perspective the impact is mainly negative. However, the proliferation of forked platforms, by increasing the overall recognition of the brand of the host platform (such as Android), can also be considered bringing positive impact for the host.

To understand and analyze this kind of competitive environment, this thesis suggests that a modular view to competitive and cooperative strategizing is needed. Competition, cooperation, and their simultaneous combination, coopetition (Bengtsson and Kock, 2000), each could be understood more specifically by utilizing a modular platform stack perspective

for their analysis. Platform stack elements, i.e., modules, can be viewed as the objects to be cooperated or competed on in the platform ecosystem. In this way, instead of being based on paradoxical relationship (Bengtsson and Kock, 2014), in the open platform context, coopetition could be defined specifically as simultaneous cooperation and competition regarding a same module.

Furthermore, instead of modeling cooperative and competitive relationships between instances of real firms, abstracted actors could be used. Abstracted actors approach allows to analyze the firm's strategic choices in a more pure sense by not only looking at the realized relationships with other firms but exposing the firm's overall strategic stance with regard to specific type of actors in the platform ecosystem.

Boundary resources as central tools for managing strategic interplay in open platform ecosystem

A second contribution this thesis makes is to theorize boundary resources as central tools to manage strategic interplay in open platform ecosystem. According to findings of this thesis, boundary resources play a diverse role in forming and controlling cooperative relationships with a multitude of complementors, enable strategic exploitation by competing platform forks, and are thus an object for strategic interplay over time between these actors. Each of these aspects are next discussed in turn.

Boundary resources are resources through which cooperative relationships are formed between various sides of a multi-sided platform, including the platform owner, a multitude of complementors, and users. Boundary resources are key interfaces that establish the openness of the platform towards the surrounding ecosystem and enable value appropriation from complementors. In addition to openness, research revealed multiple types of mechanisms that platform owners can use to control the complementors. Moreover, boundary resources are not only used to capture value from the supply side. APIs and client-side libraries, for example, are critical intermediary resources through which the usage data from the user side flows to the platform owner—in this case, to power Google's highly profitable search and ad business. To that extent, theorization of this thesis extends that of Ghazawneh and Henfridsson (2013) about the critical role of boundary resources to enable and control developer contributions.

In addition to the cooperative relationships described above, boundary resources may also be used to form competitive exploitative relationships.

This thesis illustrates that boundary resources also enable strategic exploitation through platform forking. Furthermore, similar to how the host uses boundary resources to control complementors in cooperative relationships, it can also use them to defend against exploiters. In this way, boundary resources are available and play a strategic role for both platform owner and exploiting platform.

Boundary resources also have a strategic role and hold relevance over time by being the mechanisms for strategic interplay and tying platform firms' futures together. This thesis illustrates the strategic interplay between Google and the platform forks using boundary resources from 2007 until 2015. According to this study, platform forks use combinations of forking operators around boundary resources to exploit the host. The host, in response, uses the boundary resources to defend against exploitation. Strategic maneuvering around boundary resources is instantly experienced by platform forks. Consequently platform forks again need to respond to keep up with the change, to counter any changes in boundary resources to maintain their strategic position, or to circumvent a potential bottleneck. The strategic interplay around boundary resources over time resembles distributed tuning as identified by Eaton et al. (2015). While they address distributed tuning between platform owner and complementor, this study focuses on the interplay between competing platforms.

Towards a theory of competitive advantage in open platform ecosystem

A third contribution this thesis makes is to theorize competitive advantage in open platform ecosystems. In contrast to traditional resource-based view (RBV) (Barney, 1991), this theorization is based on a relational view (Lavie, 2006; Dyer and Singh, 1998). Specifically, Lavie (2006) has presented a theorization of competitive advantage for an interfirm alliance setting that is in the following discussion proposed to be extended to open platform context.

In addition to being a traditional alliance (OHA), Android is also an open platform (Boudreau, 2010), in which Google has both open-sourced core of its platform as AOSP and granted access to complementor firms through APIs and the Google Play -app store. By viewing open platform as a specific type of alliance in which parties are more loosely connected through contracts such as open-source license and publisher agreement, this thesis suggests that Lavie's (2006) composition of four rents can be

applied to the open platform context.

First, internal rents are basically the traditional RBV-style rents (Barney, 1991) generated from internal proprietary resources. Second, appropriated rents are rents extracted from "[shared] resources that are intentionally committed and jointly possessed by the alliance partners" (Lavie, 2006, p. 645). AOSP is a prime example of shared resources in the Android context. In an open platform setting, shared resources can be interpreted to also include complements, such as apps. While IPR of the complement is typically owned by the complementor, by submitting it and distributing through the app store its possession is granted to the platform owner, and it can be considered a shared resource. The platform owner can appropriate rent from the apps, for example, through revenue sharing of the app store sales.

Third, inbound spillover rents relate "to unintended gains owing to both shared and non-shared resources of the alliance partners" and cases, "where one party exploits the alliance for its private benefit" (Lavie, 2006, p. 647). In this thesis, this is conceptualized as strategic exploitation, and platform forking, as exemplified by Amazon Fire, is viewed as one mechanism to extract inbound spillover rent in an open platform context. Fourth, outbound spillover rents are the other side of exploitation viewed from the platform owner's perspective as "unintended leakage" (Lavie, 2006, p. 648), diminishing its competitive advantage.

Summarizing the findings of this study and mapping them against these four rents, we can conclude that boundary resources are critical tools in leveraging complements (increase appropriated relational rents), through them the platform fork can gain competitive advantage by exploiting the open platform host (increase inbound spillover rent), and the host can defend itself through the same resources to protect itself from exploitation (decrease outbound spillover rents). In other words, boundary resources play a central role in accruing all three relational rents. More specifically, it can be theorized that boundary resources are the concrete managerial tool for open platform owners in increasing inbound relational rents and decreasing outbound relational rents and thus in building the platform's competitive advantage.

To be precise, instead of sub-optimizing each rent, the platform owner should maximize the remainder of inbound and outbound rents. As an example of varied approaches, Apple can be viewed as having a more closed platform strategy focusing on internal rents and appropriated rents from

developers, thus making it easier to protect against outbound spillover rent. Meanwhile, Google—with more open platform strategy—counts on appropriated rents from a variety of complementors and end users while at the same time making itself more vulnerable to exploitation.

While the perspective of boundary resources fundamentally differs with traditional RBV (Barney, 1991), boundary resources, while being open, may still be and often are owned and controlled by the host firm. Thus, boundary resource can also be seen in line with RBV theorization, except that the resources bringing competitive advantage are not closed and internal to the firm but instead are open boundary resources available to other firms in the open platform ecosystem.

5.2   Managerial implications

This thesis illustrates that open platforms create a new competitive environment with new competitive challenges and cooperative opportunities. How should firms manage competitive and cooperative strategic interplay in their platform ecosystems to increase competitive advantage? In the following discussion, preliminary managerial insights are extracted from the findings.

Balancing cooperation and competition in open platform strategy

Android's open platform strategy has been hugely successful. Mobile domain is the forerunner in digitalized business and thus firms in other industries should pay close attention to it. Most likely, the open platform approach will proliferate to other industries, providing opportunities for increased competitive advantage for its implementers.

However, combining the cooperative approach with simultaneous vertical control of the stack may lead to a situation in which other actors in the platform ecosystem face intrusive competition from the platform owner. From a third-party firm perspective, this is an unhealthy situation in which firms willing to do business in the ecosystem have to compete with the one that controls the rules for the ecosystem. For this reason, third-party firms should pay attention in choosing between platform ecosystems to do business with. To save limited resources, managers should carefully consider the pros and cons of each alternative. To mitigate these effects on

the other side, platform managers can consider and explore more ecosystemic approaches in which firm abstains from competition with too many actors in its platform ecosystem.

Boundary resources are versatile strategic artifacts for managing cooperation and competition

Managers of open platforms should understand their digital platform stack and associated boundary resources in detail. Boundary resources are the core artifacts of digital platform through which strategies, both cooperation and competition, are manifested with other actors in the ecosystem.

Regarding cooperation, boundary resources are essential generative tools to leverage value from the platform ecosystem, not only from the developers but also from any other complementors and users of the platform. Boundary resources should be viewed as versatile tools with rich strategic design purposes in leveraging complements, their distribution and control; securing compatibility of the platform; and appropriating value from the digital data provided by the users.

In addition to cooperative opportunities, boundary resources pose competitive challenges. Boundary resource that are too open may make platforms vulnerable to strategic exploitation by competing platforms. Vice versa, boundary resources of other platforms should be explored as potential targets for exploitation. This is especially relevant for firms in transition seeking to digitalize their business. Instead of building the platform from scratch, firms should explore existing open platforms as a basis on which to build a forked platform for their business. Amazon excelled in digital business, yet instead of developing a completely new platform, it chose to fork Android when moving to mobile business.

Preventing and defending against strategic exploitation

First, to prevent exploitation, managers need to pay close attention when designing the boundary resources in the first place. While maximizing the generative effect is essential for the platform's success, minimizing the weak points that may allow exploitation is also critical. It is also advisable to design boundary resources so as to leave room for maneuvering at a later point in time if needed. This is a difficult balance, which was also faced by Google managers when they chose the permissive Apache license instead of the more restrictive GPL or LGPL license for the AOSP.

A GPL license (as used in the Linux kernel project) would have forced a generative effect, but presumably they choose the Apache license because it left more room for Google (and its partners) to maneuver later.

Second, preventing exploitation of the weak points is extremely tricky because open platform boundary resources are designed in the initial stage when the platform ecosystem does not yet exist; therefore, assumptions must be made about which relevant actors to allow and who to defend from. One weak point regarding Google Android that was exposed over time is the possibility of distributing Android apps in any app store and not only through Google Play. This is manifested through the use of two boundary resources: the open APK boundary resource specifying app packaging and a permissive clause in the publisher terms and conditions allowing app developers to submit their apps to any app store. If Google had restricted app distribution, Amazon would have been unable to create a forked platform with its own app store, putting its revenues and app usage data outside of Google's control.

Third, if faced with exploitation, boundary resources, typically the ones attacked, can also be used to defend against exploiters. An example of this in our study is Google's use of the Apache license to close any further development of selected parts of the platform after forking platforms started exploiting the AOSP for their competing platforms. Furthermore, new boundary resources can be introduced to control exploitation. An example from our study is Google's introduction of a new Google Play Services client library that wrapped the APIs that Amazon had started exploiting some time earlier.

Software strategizing

Google Play Services boundary resource illustrates that in digitalized platform ecosystems, digital tools can be used for strategizing instead of legal or traditional market interventions. Software technological strategizing may offer additional benefits such as rapid deployment, customizability and more precise targeting.

However, use of software poses additional challenges as the ownership of boundary resources is contested. This is illustrated by the ongoing Google vs. Oracle legal case about Google's use of Java APIs in Android. This legal case is essentially about the copyright (i.e., ownership) of the API boundary resource. So far, the Federal Circuit has ordered and the Supreme Court has confirmed that APIs, specifically the sequence, struc-

ture, and organization (SSO) of sufficiently large APIs, are copyrighted. It is critical to note that the copyright of the API restricts its copying and use in competing platforms and not in its normal use of calling the API from an app. In an increasingly platformized world, competitive advantage, as has been argued, comes from boundary resources such as API specifications, and thus it is logical for firms to be able to protect their investments in these resources. SSO clarification is essential to differentiate between small or insignificant APIs and large APIs that basically represent a specification of a platform. It is vital that open innovation and reuse are not restricted too much by extending copyright to too small APIs.

Apart from copyright, another question is that if copying an API is protected by fair use. The second round of trial focused on this issue, and in May 2016 the District Court trial jury found that Google's copying of Java APIs is protected by fair use. Considering the extent of copying and its significance to Oracle's platform business, this was a somewhat questionable decision. However, Oracle will very likely appeal, and thus another decision is possible.

Clarification of copyright and infringement issues is essential for managers dealing with digital platforms. Unless you own the copyright to the SSO of your platform's API, you cannot prevent someone from cloning it into a competing platform. This is essentially what Google did to Sun (now Oracle). Interestingly, this is also exactly what platform forks now do to Google to ease developers' migration (basically to resubmit their apps) to their competing app stores. The difference here is that Google has purposefully published Android (incl. APIs) using a permissive open-source license, whereas Sun had more restrictive double licensing with an option to choose between a commercial license or a GPL, neither of which suited Google. It is worth noting here that unless the API has a copyright, specifying an open-source license for it is also meaningless, as the enforcement of open-source licenses relies on the acknowledgement of copyright.

5.3   Validity

Validity of the findings of this thesis is next analyzed using the common criteria for empirical research in social sciences (Kidder et al., 1986). The four tests—construct validity, internal validity, external validity and reliability—are each discussed in turn with specific argumentation from case study perspective as suggested by Yin (2009).

Construct validity refers to identifying correct operational measures for the concepts being studied. To ensure construct validity, multiple sources of evidence were used including Web-based documentation and archival records, expert survey, and interviews. Furthermore, for web-based materials, evidence was always verified from another source. In addition, survey design and research design for case studies were reviewed by experienced peers and prototypes were tested before the actual use in the research.

Internal validity refers to validity of causal relationships in explanatory case studies. The case studies presented in this thesis are mainly descriptive and exploratory, but final study and conclusions regarding strategic role of boundary resources in causal events fall into this category. Two analytic tactics, pattern matching and explanation building (Yin, 2009), were used to address the internal validity threats. Regarding pattern matching, coding was used to identify causal patterns in each case and their replication across multiple cases. Furthermore, explanation building was employed by iteratively developing the theoretical proposition using narratives developed in each case.

External validity refers to generalizability of the results outside the case study's context. This thesis employed a multiple-case study approach to replicate findings in multiple cases. As presented in the Material and Methods chapter, cases included successful and failed platforms, open and closed ones, host and forks, and platforms from geographically different markets to replicate analysis in contrasting contexts. Instead of generalizing through sampling logic from a larger population, this study employed analytic generalization (Yin, 2009) by theorizing generic constructs for a broader digital platforms context from a study of a more specific mobile context.

Reliability refers to repeatability of the research so that another investigator would arrive to same findings and conclusions. For this purpose, a case study database and research protocols were employed. Materials were added to the case study database, and coding was used to track the chain of evidence from original source to conclusions. Furthermore, research design and protocols were developed before conducting the analysis.

Furthermore, as a generic tool to improve the validity of results, this study employed an iterative approach. In other words, findings and theoretical propositions were iterated several times in several successive case

studies before arriving to conclusions. To ensure that relevant information was taken into account as broadly as possible, the study included all major platforms, all major geographic markets, and from a temporal dimension covered the whole "smartphone" era from 2006 up to last year.

5.4 Limitations and future research

This thesis had two main limitations that are discussed next, together with several avenues for future research exposed by the study.

Replicate research in other industries being digitalized

The main limitation of this thesis is that it contained data only from the mobile domain. This was due to limited resources and the need to focus the study, which naturally led to choosing the mobile domain—being the forefront in digital platform strategizing—as the context for this study. Through developments, such as advances in Internet of Things (IoT), digital platform strategizing is already proliferating to other industries, such as the car and manufacturing industries. Naturally, future studies on open digital platforms could broaden the context to these new industrial domains being currently digitalized.

Corroborate findings with managerial opinion and insight

Another limitation of this study is that it relied mainly on documentation and archival records and had limited primary interview data from firm representatives. This was due to extremely difficult accessibility of managers of leading mobile platforms. On the other hand, as was argued in the Materials and Methods chapter, open digital platform strategizing increasingly takes place openly in the Web, and thus for this context the Web served as a primary source of data. Despite this, future studies should be conducted by additional managerial opinion and insight to corroborate preliminary findings of this thesis.

Include data aspect of digitalization into the analysis

This thesis focused mainly on the software side of digitalization. As the findings pointed out, boundary resources are also elemental resources in collecting data, the other inherent aspect of digitalization. Future studies

on open platform strategies could distinguish between software and data on different aspects of openness, such as in granting access and opening for complements.

Resource-based view for open platforms

Moreover, future studies could take an even wider scope on characteristics and management of digital resources. As discussed earlier in the discussion (building upon Lavie, 2006), one potential future avenue for research would be to extend and develop a resource-based view that is more suitable and specific for open digital platforms. What are the specific kinds of digital resources and what are the specific boundary resources and capabilities needed to make a sustained competitive advantage in open digital platform ecosystems?

Open platform license

Finally, as this thesis illustrated, open-source licenses are in the center of open digital platform strategizing. However, open-source licenses used today are "old licenses" (developed back in '80s and '90s) that are not necessarily up to the business and technical requirements of open digital platforms. As the platform stack analysis employed in this study illustrates, open digital platforms are modular designs thus setting forth specific licensing requirements for modularity, bundling through modular and forking operators, linking, and use among several participants.

For example, the most widely used GPL open-source license is very vague on specifying linking. Furthermore, the linking aspect of GPL, commonly referred as the "viral" effect, has not been legally tested in court. Along the same lines, Parker et al. (2009) refer to hybrid models and argue from an economic perspective that openness should also be controllable in time dimensions, a feature that is not directly supported by existing license mechanisms. Future studies could identify the critical mechanism and levers in digital platform business and use them as requirements for designing new kinds of open-source and open-data licenses that are more specific on these issues and thus help in diminishing uncertainties in the digital platform business.

5.5   Concluding remarks

Digitalization is proliferating to various industries. This thesis studied the mobile industry as the focal case, but below the results are generalized to a wider context.

Digital products and services are by nature modular structures and designs realized as platform stacks. In an interconnected business environment, firms are no longer only relying on internal rents generated from proprietary stack elements but increasingly tap into appropriated relational rents generated from complementary and other shared stack elements. To leverage these rents, firms base their business on an open platform strategy, a platform that is selectively opened for third-party collaborators in the platform ecosystem.

Open platform strategy has multiple dimensions that can be controlled through boundary resources. Boundary resources are software tools and regulations to decide what elements, how, and in what levels are opened from the platform stack. Boundary resources can be attached to specific elements that are to be opened. To only grant access, for example, an API boundary resource can be used. To further give control to third parties, the element can be opened using an open-source license boundary resource. Furthermore, level of openness can be tuned for each chosen boundary resource, for example, for an API by altering its design and for an open-source license by selecting a specific license with chosen restrictive or permissive terms.

In addition to the cooperative side to the open platform strategy, there is also a competitive side to it both for complementors and the platform owner. First, open platform owner's vertical control easily leads to coopetitive strategizing, in which complementors face unhealthy competition from the platform owner itself. Second, from the owner's perspective, a platform that is too open may prompt competing platforms to exploit inbound spillover rent, causing the owner a negative outbound spillover rent.

Platform forking is a specific mechanism to exploit an open platform. In platform forking, a platform fork bundles several forking operators attacking open boundary resources of the host to fork both the digital platform and the business built with complementors on top of it. For the incumbent platform, platform forking is a threat, but for the new entrant, it is a new competitive strategic approach to enter the existing platform

business.

In summary, open platform strategizing results in a new competitive environment. This thesis enriches boundary resources as the central tool to manage both cooperative and competitive strategizing and their interplay in the open platform ecosystem. Boundary resources can be used in versatile ways to govern openness and cooperation, to exploit open platforms for building a competing platform fork, but also to defend against these exploiting competitors. Having the central role in connection to all relational rents in the open platform environment, boundary resources are reasoned to be critical strategic tools for building firms' competitive advantage in an increasingly digitalized, interconnected, and platformized industrial world.

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