Platform ecosystem evolution: Towards an integrative framework and implications for complements

**Joost Rietveld**
Rotterdam School of Management
Strategic Management & Entrepreneurship
rietveld@rsm.nl

**David Nieborg**
University of Toronto Scarborough
Department of Arts, Culture and Media
david.nieborg@utoronto.ca

**Joe Niklas Ploog**
Rotterdam School of Management, Erasmus University
Strategic Management and Entrepreneurship
ploog@rsm.nl

**Pursey Heugens**
Erasmus University
Rotterdam School of Management
pheugens@rsm.nl

**Abstract**
Digital platform ecosystems such as Kickstarter or Apple’s App Store owe a significant share of their overall success to third-party organizations that extend the platform’s core functionality through complementary innovations such as creative projects or mobile apps. The competitive dynamics facing such complements producers are in constant flux as platforms evolve over time. In this paper we develop a complements’ perspective on platform evolution by identifying three factors specific to platform ecosystems and exploring how these are associated with how complements compete. In a multiple case study of four digital platform ecosystems we find that, as time passes, the average demand per complement declines. Moreover, the distribution of demand for complements acquires greater ‘winner-take-all’ characteristics and becomes progressively skewed. We also find that it becomes increasingly difficult for complements producers to capture value, as average prices for complements decline and marketing-related costs increase. Finally, our results show that these evolutionary dynamics are more pronounced in ecosystems where the platform sponsor has a greater orientation towards value appropriation. We contribute by offering an integrative framework of platform ecosystem evolution and by suggesting propositions for future research to explore and unpack further.
Platform ecosystem evolution:
Towards an integrative framework and implications for complementors

Abstract. Digital platform ecosystems such as Kickstarter or Apple’s App Store owe a significant share of their overall success to third-party organizations that extend the platform’s core functionality through complementary innovations such as creative projects or mobile apps. The competitive dynamics facing such complements producers are in constant flux as platforms evolve over time. In this paper we develop a complementors’ perspective on platform evolution by identifying three factors specific to platform ecosystems and exploring how these are associated with how complements compete. In a multiple case study of four digital platform ecosystems we find that, as time passes, the average demand per complement declines. Moreover, the distribution of demand for complements acquires greater “winner-take-all” characteristics and becomes progressively skewed. We also find that it becomes increasingly difficult for complements producers to capture value, as average prices for complements decline and marketing-related costs increase. Finally, our results show that these evolutionary dynamics are more pronounced in ecosystems where the platform sponsor has a greater orientation towards value appropriation. We contribute by offering an integrative framework of platform ecosystem evolution and by suggesting propositions for future research to explore and unpack further.

Keywords: Digital, Platform ecosystems, Evolution, Complementarity, Complements, Innovation
Total word count: 11,984

INTRODUCTION

Digital platform ecosystems continue to increase their economic footprint and societal impact. The top five global firms by market capitalization—Alphabet, Amazon, Apple, Facebook, and Microsoft—all sponsor digital ecosystems, collectively facilitating interactions between billions of end-users, institutions, and businesses. The decisions for end-users to join a digital platform ecosystem are often largely contingent on the participation of third parties that produce so-called complementary innovations. Producers of complementary products, or complementors—including app developers, software developers creating add-ons to existing suites, project creators looking for funding, and other types of content producers—extend core platform
functionalities through specialized innovations, thereby contributing to an ecosystem’s overall ability to grow and capture value.\(^1\) Platform complementors vastly outnumber platform sponsors and contribute a significant share of the value created by the overall ecosystem. For example, in January 2017, Apple’s iOS App Store boasted over 2.2 million mobile applications, which collectively generated more than $60 billion in lifetime revenue for app developers.

Despite the importance of complements for digital platform ecosystems, there is a surprising paucity of research taking the perspective of complements producers. Notwithstanding recent contributions to the platform ecosystems literature (e.g., Boudreau, 2010; Boudreau and Jeppesen, 2015; Kapoor and Agarwal, 2017; Pierce, 2009; Rietveld and Eggers, 2017), we know little about complementor competition, nor about the demand for complementary goods in the context of an evolving platform ecosystem. Therefore, we argue that an evolutionary focus is particularly relevant as platforms’ technological architectures and governance frameworks are in constant flux. For example, Facebook is an extensive, complex infrastructural platform that started as a web-based property and morphed into a popular and diverse suite of mobile extension, all of which are constantly altered and updated, with each individual component allowing for deep technological and business integration with complementors. Beyond the clear managerial implications for both platform sponsors and complementors, we suggest that dynamic patterns of complementor competition warrant further research, as neither traditional management theories nor established models of industry evolution are fully equipped to predict or explain these dynamics in evolving digital platform ecosystems.

\(^1\) We use the terms “complementor” and “producers of complementary products or services” interchangeably to denote organizations that offer goods or services, or complements, that enhance the value of another firm’s (i.e. a digital platform sponsor in our case) offering (Brandenburger and Nalebuff 1997).
In this paper we address this gap by identifying three evolutionary dynamics specific to platform ecosystems and by exploring how these dynamics affect complementors: First, as platforms become more widely adopted, platform sponsors assume greater architectural control over the wider ecosystem, resulting in increased enactment of platform governance strategies affecting how complementors compete and the degree to which complementors can benefit from their innovations (Gawer, 2014; Tee and Gawer, 2009; Tiwana, Konsynski, and Bush, 2010). Second, the adoption of complements is contingent on platform adoption by end-users and there exists heterogeneity between users who join a platform ecosystem early versus those who join late (Bayus, 1987; Rogers, 2003). This shift in the composition of a platform’s end-user base likely affects the success of complements and the type of complements that will be successful (Gupta, Jain, and Sawhney, 1999; Rietveld and Eggers, 2017). Third, participation by complementors in platform ecosystems generally is markedly higher than in traditional markets because entry is accommodated by platform sponsors, who benefit from complementor diversity in the form of cross-side network externalities (Boudreau, 2010, 2012; Suarez, 2004; West, 2003). It is unclear a priori how this combination of platform-level, demand-side, and supply-side evolutionary factors affects competitive outcomes for complementors.

We unpack these dynamics by conducting a longitudinal multiple case study (Eisenhardt and Graebner, 2007; Gibbert, Ruigrok, and Wicki, 2008). Specifically, we analyze how demand for complements, the evenness of the distribution of the demand for complements, and salient indicators of value capture for complements producers shift over time within four paradigmatic digital platform ecosystems: Apple’s iOS App Store (mobile applications), Kickstarter (crowdfunding), Kiva (microfinancing of entrepreneurial loans), and Valce’s Steam (digital PC games). These cases all entail digital ecosystems that are organized around a platform sponsor
who sets and enacts the shared objectives of the overall ecosystem, and complementors who make platform-specific investments in order to enter or participate in the ecosystem (Jacobides, Cennamo, and Gawer, 2017). Not only are these platforms widely regarded as industry leaders in their respective market segments, they also have a significant history, allowing us to retrace their development over a period of several years. We draw inference from combining qualitative data from secondary sources with quantitative data from longitudinal datasets for each case.

Our case analysis produces four main findings of how platform ecosystem evolution is associated with changing competitive dynamics for complements producers. First, our analysis suggests that the average demand per complement declines as platform ecosystems evolve. This counterintuitive finding runs against the predictions of network externality theory (Katz and Shapiro, 1985, 1986), which holds that complementors in platform ecosystems with larger user-bases will benefit from stronger cross-side network externalities. Second, our findings add nuance to existing theories of platform competition by observing that the benefits of a larger end-user base are not uniformly distributed due to platform sponsors exerting greater architectural control through redistributive governance strategies. We find that the distribution of demand for complementary innovations becomes markedly skewed, to the benefit of a small group of “superstar” complements. Third, our analysis suggests that complements producers’ ability to capture value from their innovations is increasingly compromised as the platform evolves. We observe that average prices fall while the costs related to marketing complementary innovations increase. Fourth, our findings suggest that these dynamics are more pronounced in cases where the platform sponsor is strongly oriented towards capturing value.

With this study we aim to make three contributions: First, we answer recent calls for research taking an evolutionary perspective on platform ecosystems (McIntyre and Srinivasan,
Research of this kind becomes increasingly relevant because digital platforms’ technological infrastructures and governance frameworks are highly malleable and therefore result in significant implications for how platform sponsors manage their ecosystems. We contribute by proposing an integrative framework that outlines how platform evolution is associated with competitive dynamics for complementors. Second, we deepen our understanding of platform ecosystems by shifting the focus from inter-platform competition to intra-platform competition. We explore the implications of complementors being subject to platforms’ changing governance frameworks (Jacobides et al., 2017; Nambisan and Baron, 2013), while also giving consideration to the size and the composition of platforms’ user groups. Third, our framework generates four propositions postulating when complements producers will be most likely to benefit from their innovations and on which type of platforms. These propositions not only offer a fertile ground for future research, they should also be of interest to entrepreneurs given their salient managerial and strategic implications.

PLATFORM ECOSYSTEMS: DEFINITION AND CONCEPTUALIZATION

What sustains the constant reconfiguration of platform ecosystems is that platform sponsors offer modular interfaces embodied in products, services, or digital technologies. These interfaces enable transactions and govern interactions between two (or more) distinct groups of users, here defined as complementors and end-users (see Figure 1).\(^2\) Platform sponsors, at the core of the platform ecosystem, exert architectural control over a platform’s technological infrastructure,

\(^2\) We follow Gawer’s (2014) integrative perspective of platforms as markets and platforms as technological architecture in our conceptualization of platform ecosystems. Furthermore, the class of platform ecosystems that we study in this paper aligns most closely with Gawer’s definition of “Industry platforms” (p. 1244).
and set the conditions for entry and subsequent participation. Complementors, on their part, typically extend the platform’s core functionality through co-specialized innovations that connect via one of the platform’s physical or digital modular interfaces (Baldwin and Clark, 2000; Baldwin and Woodard, 2009). Platforms and complements are interdependent given their group-level complementarities, and complementors often make investments that are not fully fungible in order to enter or participate in the ecosystem (Jacobides, Knudsen and Augier, 2006).

--- INSERT FIGURE 1 HERE ---

Platform sponsors create value in two primary ways. First, platform sponsors must decide on a price structure that entices users on both sides to join the ecosystem (Rochet and Tirole, 2003). Platform ecosystems often exhibit cross-side network externalities, as the value of a platform to each of the user groups is contingent on the degree of participation by other user group(s) (Katz and Shapiro, 1985, 1986). Moreover, demand elasticity relating to cross-side participation often differs between sides (Parker and Van Alstyne, 2005). For example, while readers’ willingness-to-pay for magazines is only moderately dependent on the availability of advertisements, advertisers’ willingness-to-pay for advertising space in magazines on the other hand is strongly dependent on magazines having a large reader-base. Platform sponsors solve this issue of asymmetric cross-side elasticities by over-charging one side of the platform while subsidizing the other – sometimes to the extent that platforms are sold at, or below, cost to one group of users. By identifying each side’s demand elasticity for cross-side participation and by charging both groups of users accordingly, platform sponsors stimulate the overall growth of the ecosystem and ensure the proportional participation of each user group.

Second, platform sponsors create value by managing their ecosystem and its members through enforcing architectural control in the form of platform design and platform governance
One of the key design choices platform sponsors face is deciding on the level of platform openness. Platform openness refers to any restrictions placed on the participation in the development of the platform itself, its commercialization, or its use (Eisenmann, Parker and Van Alstyne, 2009). Platform sponsors that welcome joint development and commercialization of the technological infrastructure (e.g., the open-source Linux operating system) can expect higher adoption rates at the cost of forgoing the ability to appropriate substantial value from the platform-complements bundle (Schilling, 2009; West, 2003). Platform openness can also refer to the rules for platform entry by users. While platforms generally benefit from having high participation rates on both sides of the ecosystem, entry into some ecosystems is subject to strong quality controls (e.g., video game developers for Nintendo consoles in the 1980s), whereas entry into others is largely accommodated (e.g., application developers for Android’s App Store). Deciding on the degree of openness in the form of entry barriers, or a lack thereof, ultimately boils down to a trade-off between diversity and the platform sponsor’s control over who may participate, and when (Boudreau, 2010). In this sense, open platforms typically enjoy a wider range of complement diversity at the cost of greater variability in quality and performance.

Beyond platform design, platform sponsors can manage the depth and breadth of their ecosystems by devising and enacting platform governance strategies. The platform governance framework refers to the strategic instruments that collectively impact the platform’s overall value creation potential and the extent to which it can capture a portion of this value (Ceccagnoli et al., 2012; Wareham, Fox and Giner, 2014). While as of yet the literature on platform governance is relatively scant, examples of platform governance strategies include platforms investing in the development of complementary innovations, or directly entering the market for complements, either to round out the ecosystem’s pool of complementary innovations or to enhance its value.
appropriation through head-on competition with existing complementors (Gawer and Henderson, 2007; Pierce, 2009). Other governance strategies include selectively promoting complementary innovations to increase awareness for a particular category of complements, or to reward or induce exceptional behavior (e.g., exclusivity agreements) (Rietveld, Schilling and Bellavitis, 2017). From this perspective, platforms have been analogized to “semi-regulated marketplaces” with platform sponsors acting as “ecosystem governors” (Boudreau and Hagiu, 2009).

**EVOLUTIONARY DYNAMICS IN PLATFORM ECOSYSTEMS**

Thus far we have taken a predominantly static perspective on platform ecosystems. Yet, as becomes apparent in reviewing the instruments a platform sponsor has at its disposal, successfully managing a platform ecosystem is inherently a *dynamic* process (Gawer, 2014; Gawer and Cusumano, 2014). Platform sponsors seeking to maximize externalities from cross-side platform participation must constantly facilitate interactions between their users by reviewing and updating a platform’s technological infrastructure and governance framework, all the while sustaining architectural control and exploiting their ability to capture value (Tiwana et al., 2010; Tiwana, 2015a). In short, digital platform ecosystems dynamically evolve over time.

**Evolutionary dynamics at the platform-level**

As platform ecosystems become more widely diffused, platform sponsors solidify their position and reduce their dependencies on individual complementors. Early in a platform ecosystem’s evolution, platforms must incentivize complementors to join in the absence of a large user-base while simultaneously facing uncertainty over the ecosystem’s future position in the competitive
landscape (Schilling, 1998; Suarez, 2004). In order to solve this canonical “chicken-and-egg” problem (Rochet and Tirole, 2003), platform sponsors tend to resort to subsidized development of complementary innovations and other (financial) incentives (e.g., bundling, joint-marketing) for complementors. This puts complementors, particularly those with a prior reputation for high quality, at a favorable bargaining position vis-à-vis the platform sponsor. Later in the evolution of the platform ecosystem, when the ecosystem’s population of end-users and its stock of complementary innovations has grown, platform sponsors can afford to be more selective in terms of the support given to complementors. While incumbent, superstar, or other kinds of reputable complementors can continue to count on the platform sponsor’s support throughout the ecosystem’s evolution, support for the overall complementor pool, and particularly for those of lower quality, will decline as the platform ecosystem evolves.3

Additionally, platform sponsors increasingly enact strategies through which they solidify their architectural control and shape the ecosystem’s competitive landscape (Jacobides et al., 2006; Tiwana et al., 2010). First, as platform sponsors increase their bargaining power over complementors they progressively exploit their architectural advantage within the ecosystem. One tactic certain platform sponsors use to leverage their architectural advantage is entering the market for complementary innovations either by absorbing complementary functionality into the platform’s technological core, thereby rendering third-party offerings obsolete (e.g., Apple integrating flashlight functionality into its iOS operating system), or by commercializing internally-developed complements that directly compete with third-party offerings (e.g., Nintendo releasing first-party video games for its own game consoles) (see also Eisenmann et al.,

---

3 The extent to which this shift in bargaining power occurs clearly also depends on the ecosystem’s position in the competitive landscape. Dominant platform ecosystems enjoy greater uptakes in architectural control and bargaining power than platforms with inferior market positions. However, since the focus of this paper is on evolutionary dynamics within platform ecosystems, we consider inter-platform dynamics to be beyond the scope of this paper.
While such predatory behavior by platform sponsors can discourage entry by complementors and impede ecosystem-level value creation early in the platform’s evolution, later, when there exists a critical mass of users on both sides of the ecosystem, the platform sponsor can deploy such strategies without significant loss of value creation.

Second, as the pool of complementary products grows and expands in terms of differentiation, platform sponsors increasingly enact governance strategies that function as sorting mechanisms, meant to improve the matching of complements with end-users. This is particularly salient in digital platform ecosystems, where market entry is facilitated by the availability of accessible and affordable development tools (Brynjolfsson, Hu and Smith, 2003). To minimize end-users’ search costs, platforms often embed recommender systems in their technological infrastructures, providing heterogeneous end-users with a curated selection of complements (see also Bakos, 1997; Brynjolfsson, Hu and Smith, 2010). When not hand-curated, the algorithms underlying these redistributive sorting mechanisms are non-random and strongly dependent on the platform sponsor’s potential for value capture (Rietveld et al., 2017). As a result, popular or high-quality complements are significantly more likely to receive selective promotion by the platform sponsor. Fleder and Hosanagar (2009) found that this bias can set in motion a rich-get-richer effect where recommender systems disproportionally promote certain complements at the cost of others as the ecosystem evolves.

**Evolutionary patterns on the demand-side**

The ecosystem’s evolution, and complements competitive environment in particular, is further affected by temporal dynamics on the demand-side. While it is well-established that end-users
join platform ecosystems in a non-linear fashion, less attention has been paid to differences between early and late platform adopters (Adner, 2004; Adner and Levinthal, 2001). The diffusion of innovations literature has long asserted that there exist heterogeneity between early and late adopters of an innovation (Rogers, 2003): early adopters have a higher willingness-to-pay for innovations (Karshenas and Stoneman, 1993), they exhibit greater risk-seeking behavior (Geroski, 2000; Leonard-Barton, 1985), they have greater preferences for novelty (Hirschman, 1980; Kahn, 1995), and they search more deeply for information on competing innovations (Taylor and Todd 1995; Zeithaml, 1988). Yet, in taking a complementor perspective it becomes apparent that not only do these differences affect competitive dynamics between platform ecosystems, they also affect competition within ecosystems as the adoption of complements is subject to the size and the composition of the platform’s end-user base. That is, complementary goods are contingent innovation decisions (Bayus 1987, Rogers 2003).

In contingent innovation decisions, an end-user’s predispositions towards the base innovation generally also apply to the focal innovation (Rogers 2003, Shih and Venkatesh 2004). In other words, the factors distinguishing early platform adopters from late platform adopters also characterize their interaction with the complements on a platform. Rietveld and Eggers (2017) explored the implications of this changing composition of the end-user base in the context of the console video game industry. They found that, despite an absolute growth in a video game console’s end-user base, video games’ average sales performance declined as the console became more widely diffused. Although increased competition between game developers explained part of this effect, they found that the negative performance effect was more pronounced for games based on novel intellectual property (which are seen as risky by late adopters that do not seek novelty) and that the gap between popular and less popular video
games widened as more risk-averse late adopters moved into the platform and sought to avoid purchasing mistakes (see also Gupta et al., 1999). In sum, complementors’ market potential and competitive dynamics are not only determined by the size of a platform’s end-user base, but also by the evolving composition of the end-user base in the platform ecosystem.

**Evolutionary patterns on the complementor-side**

Apart from the positive cross-side network externalities arising from a growing, albeit heterogeneous end-user base, research on platform ecosystems has highlighted the importance of same-side network externalities, defined as the effect of more complements entering a platform ecosystem (see Figure 1). Increases on the end-user side not only expand complements’ market potential, it also triggers additional entry by complement producers. This incentive for entry can trigger a competitive crowding effect when the platform entry-rate by complementors outweighs the platform adoption-rate by consumers. Such “over-entry” can negatively affect complementors – especially when too many competitors are active within the same category on the platform (Boudreau, 2012). The combined net-effect of same-side and cross-side network externalities is anything but straightforward and may lead to positive or negative results, depending on the specifics of the platform (Parker and Van Alstyne 2005). Boudreau and Jeppesen (2015) explored these dynamics in the context of an online platform for video game modifications and found that modders’ contributions were positively correlated with additional platform usage and negatively correlated with increases in the number of competitors. In the end, they found a weak negative net-effect for the combination of these factors, suggesting that the competitive crowding effect outweighed the positive cross-side network externality.
The potentially harmful same-side network effect on the complementor-side is further exacerbated by digital platforms’ often low to negligible costs of producing and selling complements. Unlike the evolution of traditional (non-digital) industries, where endogenous sunk costs rise over time and where there is a constant pressure to lower the marginal costs of production resulting in progressively lower entry rates and shake-outs of lagging incumbent firms (Klepper, 1996; Sutton, 1991), digital platform ecosystems are characterized by virtually unlimited shelf-space and many complements producers incur zero marginal production costs from the onset (Bakos and Brynjolfsson, 1999; Brynjolfsson et al., 2003). As a result, the pool of available complementary innovations in many digital platforms accumulates over time, as entry rates are stable or positive while complementors’ platform desertion rates are consistently low.

Prior to exploring the implications of these evolutionary dynamics for complementors and their innovations, we point to their interdependencies. In particular, the saliency of a platform’s governance framework is endogenous to the ecosystem’s pool of end-users shifting from being composed of primarily early adopters to a mix of early and late adopters. Displaying greater risk aversion and relying more strongly on readily available information and external cues for making adoption decisions, late platform adopters stand to gain more from platforms’ redistributive strategies than early adopters. Likewise, platform sponsors’ bargaining power is endogenous to the continuous entry and growing supply of complements in the ecosystem. As more complements become available so does the platform’s mobility vis-à-vis any individual complement in particular. This clearly puts the platform sponsor in a favorable position to increase its bargaining power vis-à-vis the majority of complement producers.
METHODOLOGY AND METHODS

To develop an understanding of how platform evolution affects competitive dynamics for complements producers, we use a multiple case-study methodology in which we combine longitudinal datasets with qualitative insights from four digital platform ecosystems—the iOS App Store, Kickstarter, Kiva, and Steam. Case study research is well suited for studying emerging phenomena with the purpose of developing new theory (Eisenhardt, 1989; Stake, 2013), especially when the examined phenomenon is dynamically evolving over time (Langley, 1999). A multiple case study approach generally provides a stronger basis for theoretical inference than a single case study (Stake, 2013; Yin 1994), as it allows for cross-case replication and generates insights on whether findings are “idiosyncratic to a single case or consistently replicated by several cases” (Eisenhardt and Graebner, 2007: 27).

Case selection, external validity, and internal validity

Given the intensity of our data collection efforts (see below), we opted for a concise sample of four cases; a number which is nonetheless generally seen as sufficient for reaping the benefits associated with multiple case designs, which include external validation through the repeated verification of initial research findings (Stake, 2013: 53). We confront concerns related to external validity and generalizability by selecting market-leading platforms from different industry contexts as our cases (Gibbert et al., 2008). We focused on platforms that all have a significant history, allowing us to retrace their development over a period of several years. Since all cases involve mature digital platforms cultivating a wide range of complements, they are sufficiently comparable to ensure the generalizability of our findings. Yet, they are also
importantly different on at least one theoretically salient dimension: the extent to which the platform sponsor pursues value appropriation for itself and its shareholders (see Table 1). Kiva, for example, is a non-profit organization aimed at reducing poverty, while Kickstarter is a public benefit organization that allows for public benefit to be a charter purpose in addition to shareholder wealth creation. Apple’s and Valve’s legal structures, on the other hand, dictate that they are fully focused on maximizing value for shareholders. While we did not encounter any previous studies pointing to the importance of platform sponsors’ legal structures, it is well known that platform sponsors determine the ecosystem’s objective, or system-level goal (Gulati, Puranam and Tushman, 2012), and that this shared objective is at least partially driven by the platform sponsor’s fiduciary duties (e.g., shareholder wealth creation).

--- INSERT TABLE 1 ABOUT HERE ---

In addition to external validation through theoretically informed cross-case replication, we aim to enhance the internal validity of our findings by taking several measures conducive to within-case process tracing (George and Bennett, 2005; Gibbert et al., 2008). First, we developed a clear research framework in which we identified a comprehensive list of evolutionary patterns in digital platform markets, which we use as independent variables and as a basis for structured within-case analyses. We thus first set out to confirm that these antecedent conditions are present in our cases, and only then proceed to match them to observed outcomes. Second, we carefully establish evolutionary patterns of complementor competition as they occur in each of our cases separately, and only proceed to look for cross-case regularities in subsequent analytical steps. We also strive to rule out spurious correlations driven by macro-economic factors, as our cases began operations in different years and are active across many different countries. Third, we started our case analyses by taking a broad perspective on platform evolution, ensuring that we
would pick up on any empirical regularities as they presented themselves. In our results section, we only document those findings that we structurally observe across all four cases.

**Data collection**

For each case, we collected data over a period of multiple years, using a variety of sources (see Table 1). We collected data starting from cases’ founding dates up to the most recent point in time for which accurate data was available. First, for each case we collected time-varying observations on the number of end-users (broken out by types of end-users) and the number of complements producers (and the number of complements). These data also include information on meaningful measures of complement performance, such as the number of times a video game was downloaded on Steam or the average success rate of projects posted on Kickstarter in a particular month. Second, consulting mainly secondary online sources such as the platform’s website, financial reports, and trade publications, we collected qualitative data on major developments in cases’ history and on how these affected competitive dynamics for complementors. We used these qualitative data to compile reports for each of the cases detailing which governance strategies platform sponsors enacted, when, and how this affected end-users and complementors. Triangulation of qualitative insights on the enactment of governance strategies and other major developments with quantitative data on platforms’ demand- and supply-side evolution further strengthens the empirical grounding for our findings.
Case descriptions

Below we provide brief descriptions of our four cases based on the three evolutionary patterns described earlier: governance changes, demand-side evolution, and complementor-side evolution. Appendices 1 and 2 provide tabulated overviews of these dynamics. Consistent with our theoretical framework, we observe that over time: 1) platform sponsors assume greater architectural control through the enactment of governance changes, 2) platforms’ user bases expand significantly, both in terms of size and heterogeneity, and 3) complementors’ entry rates remain stable or keep growing. All four cases clearly are platform ecosystems given that they are organized around an anchor that is a platform and that there exist group-level complementarities that involve complementors making non-fungible platform-specific investments to enter or participate in the ecosystem (Jacobides et al., 2006; 2017).

iOS App Store. July 2008 marked the launch of the iOS App Store, the digital marketplace associated with the Apple iOS mobile operating system that powers the iPhone and iPad. The iOS App Store allows users to download externally developed applications that complement the device’s core functionality. Third-party developers must pay an annual license fee of $99 USD to distribute apps via the iOS App Store and have their apps undergo extensive review by Apple. Apple also takes a 30% share of all app-related revenue on the platform. The app developer pool is particularly diverse, ranging from mature incumbent developers to start-ups, hobbyists, hackers, students, and artists. Applications are similarly diverse, spanning categories such as “Games”, “Business”, “Education”, “Lifestyle”, “Shopping”, and “Travel”.
Soon after its launch, the App Store attained a dominant market position, as its user base grew exponentially from 13.2 million in 2008 to more than 1.3 billion in 2016.\textsuperscript{4} Similarly, the number of app developers increased from approximately 23 thousand in 2009 to over 494 thousand in 2016. A similar trend can be observed for the number of available apps: growing from 100 thousand in 2009, to more than 2.2 million apps at the end of 2016.\textsuperscript{5}

Early changes in platform governance focused on improving the platform’s attractiveness for app developers. In 2009, Apple allowed for in-app purchases, leading to the popularization of the “freemium” business model. Freemium apps can be downloaded for free and developers can generate revenue by charging end-users for optional app features and functionalities (Rietveld, 2017). Additionally, Apple promoted in-app advertising with the launch of “iAd” in 2010. iAd allowed developers to directly embed advertisements into their apps, unlocking income from advertisements as a potential additional revenue stream. Allowing for in-app purchases and advertising offered significant incentives for app developers to enter the platform, as is reflected in the sudden hike in entry in 2010, when 300,000 new apps became available in the App Store.

In 2012, the competitive dynamics for app developers changed noticeably when Apple implemented three redistributive governance changes. First, the introduction of the “Editor’s Choice” section on the App Store’s front page showcased apps handpicked by an anonymous group of Apple curators. Featured apps enjoy a significant boost in sales, as consumers derive value from the platform’s endorsement in an overly crowded market characterized by strong variance in app quality. Second, the introduction of the “Free App of the Week” feature offered

\textsuperscript{4} Note that the first iOS devices were introduced in 2007, whereas the App Store became available a year later.  
\textsuperscript{5} We report cumulative complementor and user statistics for the iOS App Store and for Steam, whereas we report incremental (yearly) statistics for Kickstarter and Kiva. This is a deliberate choice, owing to the strict time constraints on complements’ lifecycles on Kickstarter (projects) and Kiva (loans), compared to the virtually unlimited lifecycles of complements on the App Store (apps) and Steam (digital games).
time-limited access to a free, premium-priced app. App developers that are chosen for this recognition are compensated by Apple on a per download basis. Third, the introduction of the algorithmically-driven recommendation feature “Genius” was introduced to suggest apps based on a user’s past purchases and downloads. Moreover, Apple undertook major changes to aid app discoverability over time. For example, in 2015 it altered its App Store search algorithm by reducing the importance of keywords in lieu of relevance of similar apps related to the search query, thereby mainly benefiting already popular apps. Then, in October 2016 Apple introduced “Search Ads”, allowing developers to pay for keyword-based ads to appear next to organic search queries. Taken together, these changes only benefit a relatively small segment of well-capitalized app developers while limiting the opportunities for new entrants.

**Kickstarter.** Kickstarter was launched in 2009 as an all-or-nothing reward-based crowdfunding platform. It hosts 15 categories of creative projects, ranging from music and theater to cinematic productions. “Creators” seek funds within a fixed timeframe of 60 days or less. “Backers” are those who support projects by pledging any desired amount with a minimum of $1 USD. A backer’s account will only be charged if the project reaches or exceeds its funding goal within the set timeframe. Unlike venture capital or certain other crowdfunding platforms, neither Kickstarter nor backers take an ownership stake in projects. Typically, backers are offered certain rewards, such as public recognition or a custom version of the project outcome. Kickstarter retains 5% of all donations to any successfully funded project.

In 2010, nearly 600 thousand backers made pledges to more than 11 thousand projects. In 2013, the number of backers peaked at 2.5 million and has fluctuated since. We observe a shift in backers’ behavior as the rate of backers supporting more than one project on the platform has remained stable since 2013, despite the constant influx of new projects (suggesting that later
backers likely support only one or a few projects, whereas earlier backers keep actively supporting new projects). The number of posted projects increased at a steady annual pace until 2015, when it peaked at nearly 80 thousand projects and has slightly dropped since.

Initially, governance changes for the Kickstarter platform focused on improving projects’ chances for success, while subsequent changes were aimed at reducing risks for backers, accommodating platform entry for creators, and certifying high-quality projects. To this end, in 2011, Kickstarter shortened a project’s maximum funding cycle from 90 to 60 days after it found that projects with shorter funding cycles tended to be more successful. In 2012 Kickstarter introduced far-reaching regulations regarding a project’s description, presentation, and reward scheme. Since then it is mandatory for creators to list “Risks and Challenges” and prohibiting creators from using simulations showing what a project might be capable of. These regulations were meant to manage expectations and aid backers in making better decisions. Later, in June 2014, Kickstarter introduced “Launch Now,” an algorithm-driven screening process that checks if the minimum criteria for aspiring Kickstarter projects are met. This feature reduced the dependency on manual screening and allowed for more efficient platform entry by creators. Finally, in 2016, Kickstarter introduced “Projects We Love”, a certification program where a small number of high-quality projects is selected by an editorial team of Kickstarter employees. Similar to apps featured in Apple’s App Store, such featured projects enjoy a significant increase in visibility because they are prominently displayed on Kickstarter’s front page, and thus have greater chances of meeting and exceeding their funding goals.

**Kiva.** Kiva is a non-profit microfinancing platform. Its mission is to alleviate poverty by allowing individuals to make small loans to borrowers who are primarily based in developing countries. Borrowers are either individuals or small groups of people requesting loans for various
purposes, such as paying for a child’s tuition fees or boosting local agricultural activity. A typical loan is around $800 USD, coming from 25 lenders contributing $32 USD each. The vast majority of loans on Kiva are administered by a “Field Partner”, which is a local for-profit organization that acts as an intermediary between the lender and the borrower. Kiva’s lending process breaks down as follows: First, the Field Partner checks a borrower’s creditworthiness. If successful, the Field Partner approves the loan and forwards the request to Kiva. With Kiva’s help, the Field Partner then posts a description that consists of information on the borrower, the loan’s purpose and timeframe. When the borrower has fully repaid the loan, lenders receive their money back, with zero interest, and they can then decide to either withdraw their money from the platform or support other loans. The vast majority of the loans are funded and 97.1% are fully repaid. A typical loan takes less than a week to be funded and 300 days to be fully repaid.

Since Kiva’s launch, both the number of Field Partners posting loans and the number of lenders have increased consistently. The platform started with a single Field Partner posting 36 loans in 2005. In 2009, the number of Field Partners increased to 103, posting over 60 thousand loans. Five years later there were 262 Field Partners posting upwards of 167 thousand loans. Simultaneously, the number of lenders rose from 203 in 2005, to more than 1.3 million in 2009, to nearly 4 million in 2014. That said, the share of first-time lenders decreased over time, suggesting that the majority of loans are supported by avid lenders who joined the platform soon after its launch, while later lenders only support a small number of loans.

Kiva’s governance framework is structured differently compared to the other three cases. First, Kiva focused on implementing changes that were particularly favorable to Field Partners, instead of shifting focus toward facilitating end-users. Second, Kiva implemented fewer governance changes compared to the other three platforms. In 2009, Kiva changed its foreign
currency risk policy by letting lenders cover currency exchange-related losses for Field Partners, if such losses exceeded 25%. Later, in 2012, Kiva further decreased the currency exchange loss threshold to 10%, further lowering the operating risks for Field Partners. Notwithstanding these generally favorable governance policies, Kiva also implemented a redistributive governance policy with the introduction of “social performance badges”, which certify a Field Partner’s excellence in specific focus areas. Kiva recognizes seven badge categories including “Anti-Poverty Focus,” “Innovation”, and “Entrepreneurial Support.” Performance badges increase the visibility of Field Partners and make it easier for lenders to select loans by Field Partners that excel in a particular area. Field Partners that are awarded badges are monitored closely by Kiva and badges can be revoked in case of weak performance or inappropriate behavior.

**Steam.** To streamline the digital distribution of games on PCs, game developer and publisher Valve launched Steam in 2003. Initially, Valve intended Steam to deploy automatic updates for its online multiplayer game *Counter-Strike*. In 2004, Valve released the much-anticipated title *Half-Life 2*, which required players to use the Steam platform to install and play the game. Considering *Counter-Strike*’s and *Half-Life* 2’s success, Valve started negotiations with third-party game developers and in 2005 Valve added the first externally developed games to the platform. As a result, Steam quickly emerged as a market-leader and today the platform services over 75 percent of the global market for digitally distributed PC games. Similar to Apple’s App Store, developers pay Valve a 30% revenue share on all game-related income.

Both the number of end-users and the pool of developers increased exponentially since Valve opened the platform to third-party developers. The number of player accounts grew from 13 million in 2007, to 50 million in 2012, and 125 million users in 2015. Similarly, the number of developers increased dramatically, from six developers in 2005, to 41 developers with 178
games in 2007, to 462 developers having released 1,611 games in 2012. In 2016, Valve reduced
the barriers to platform entry for developers (discussed below), which increased the number of
developers exponentially to 5,455 developers collectively launching 11,477 titles.

As for its governance framework, Valve initially focused on making Steam more
accessible to developers, while later it shifted focus to facilitating end-users in guiding their
purchasing decisions. In 2008, Valve granted developers access to its application programming
interface “Steamworks”, which allowed for easier integration of game code with the Steam
platform. In 2011, Valve integrated functionalities for in-game purchases into Steamworks,
enabling developers to operate the freemium business model. A significant change in platform
entry occurred in 2012, when Valve switched from manual platform access to introducing
“Steam Greenlight”, which relegated entry screening to end-users. During the greenlight process
users could vote for games, and titles surpassing a certain threshold were typically granted access
with Valve retaining veto power. In 2017, Valve decreased platform entry barriers further by
introducing “Steam Direct”, allowing any developer platform entry by filing out an online form
and paying a standard $100 USD licensing fee. Other major changes in platform governance
concerned redistributive matters. In 2014, for example, Steam’s search algorithm was changed
for the first time as part of the “Discovery Update I.” Since then, the selection of games being
displayed on the platform’s storefront strongly depends on end-users’ prior purchases and game
usage. In 2016, Steam’s search algorithm changed again with “Discovery Update II.” From then
on, the selection of games displayed on the platform’s storefront was dependent on games that
are popular with other users, resulting in already popular games gaining even greater visibility.
EFFECTS OF PLATFORM EVOLUTION ON COMPLEMENTOR COMPETITION

In all four cases we observe that platform evolution is associated with complementors’ competitive dynamics in ways that are multi-faceted and sometimes counter-intuitive. Below, we further unpack four persistent evolutionary dynamics by presenting empirical evidence from each of our four cases. We end each section by offering a proposition that captures how platform ecosystem evolution affects complementors. In Figure 2 we integrate our main findings into a conceptual framework of platform ecosystem evolution. The boxes on the left-hand side are the product of our theory section, while the proposed relationships with the boxes on the right-hand side of the model are a direct result of our case study analysis.

--- INSERT FIGURE 2 HERE ---

Evolutionary patterns in the average demand for complements

Among all cases we find strong evidence that the average demand for complementary goods declines as platform ecosystems evolve. For example, Figure 3 illustrates the average success rate for creative projects on Kickstarter between June 2012 and June 2017. The evidence shows that the success rate fell from 41.62% in 2012 to 35.36% in 2016, meaning that fewer projects received sufficient funding. Competitive crowding only partially explains this trend: the number of projects launched did not change significantly during this timeframe, and neither did the inflow of new backers. Notably, the steep drop in projects’ average success rate in June 2014 coincided with the introduction of “Launch Now”, the governance change that automated project screening and evaluation for creative projects looking to enter the platform.

--- INSERT FIGURE 3 HERE ---
The other three cases exhibit a similar decline in demand for complements. On Steam we find that the median downloads for paid games dropped exponentially during our data collection period.\(^6\) In 2007, a typical paid game generated 713,959 downloads. This number dropped to 633,552 downloads in 2011, and plummeted to 74,361 downloads in 2015. On Kiva, the average time it took to fund a loan, a key performance indicator given that practically all loans get funded (e.g., Allison et al., 2015; Gallak, Small and Stephen, 2011), increased as well. In 2007 it took only 1.18 days for a loan to get funded, whereas in 2014 this increased to 8.57 days. While we do not have access to systematic download or revenue data for apps on the App Store, anecdotal evidence suggests that here, too, the average revenue and download performance of applications decreased as the platform evolved.\(^7\) Our first baseline proposition therefore is:

**Proposition 1:** As platforms evolve over time, the average demand per complementary good will decline.

**Evolutionary patterns in the distribution of demand for complements**

Our second finding is that as platform ecosystems evolve, the demand distribution for complementary goods becomes progressively skewed. This point is illustrated by Figure 4, which depicts the share of cumulative downloads for paid games on Steam in a given year, broken out by percentage-based popularity ranks for games released in the same year. For

---

\(^6\) We report the median as statistical moment for games on Steam given that the distribution of downloads is highly skewed; reporting average downloads by year therefore would not be representative as this measure is biased by a few hit games residing at the top of the market. Furthermore, we base our reported measure solely on the sample of paid games (i.e., we exclude freemium games) to make the interpretation of this measure more meaningful.

\(^7\) See for example: https://techcrunch.com/2016/06/21/the-apple-app-store-graveyard/ (accessed November, 2017)
example, the figure shows that in 2007, the top 20% of the most downloaded games accounted for approximately 66% of all downloads of games released in that year. While skewed demand distributions are typical for markets for information and entertainment goods, which are known for “blockbuster” or “winner-take-all” effects (e.g., Binken and Stremersch, 2009; Chung and Cox, 1994; De Vany and Walls, 1996), our findings show that this asymmetry increases with time. Going back to our Steam example, the share of downloads generated by the top 20% of games released in 2016 increased to 90% of all downloads by games released in that year. In other words, out of 4,153 paid games released in 2016 on Steam, only 831 games accounted for 90% of the approximately 234 million downloads of games released in that year.\(^8\)

--- INSERT FIGURE 4 HERE ---

This growing blockbuster effect is not restricted to Steam. Kiva follows a similar trend as depicted in Figure 4. While the overall skewness is less pronounced, we find that in 2009 the top 20% of best performing Field Partners (in terms of dollars lent to successfully funded loans) accounted for 42% of all dollars lent. In 2014 this had increased to 66% of all dollars lent. We observe a similar dynamic for Kickstarter, where the share of successful projects raising over $100,000 USD grew at the expense of smaller projects. The share of successful projects raising less than $100,000 USD fell by 17% from 2012 to 2017, whereas the share of successful projects raising over $100,000 USD grew by 302% during that same timeframe. Notably, in the iOS App Store –where the winner-take-all effect has been well-documented\(^9\)- we observe substantial differences between the most successful app developers and the population average: In 2016 the

\(^8\) Notably, the distribution of downloads for games residing within the top 20% category is also highly skewed as a small number of games account for the vast majority of downloads within this subset of blockbuster games.

\(^9\) Many articles in trade publications point to the growing discrepancies in the app population (see for example: https://blog.branch.io/mobile-app-developers-are-suffering/?aliId=11773944 accessed November, 2017)
average app developer published 4.49 apps, whereas the average developer of a top-10 listed application (by number of downloads) published 52.28 apps. Our second proposition therefore is:

**Proposition 2:** As platforms evolve over time, demand for complementary goods will become progressively unevenly distributed, such that a smaller portion of successful complements will account for a larger share of the overall demand.

**Evolutionary patterns in the appropriation of value from complements**

Third, we find that it becomes increasingly hard for complementors to benefit from their innovations as platforms evolve. In addition to the decline in demand, we find that it becomes more difficult for complementors to capture value, as average prices for complements decline while marketing costs increase. On the iOS App Store, for example, we note that the average price of apps declined since 2009. Figure 5 shows that the average price for apps fell from $3.00 USD in 2009 to $1.14 USD in 2016, a drop of 62\%.\(^{10}\) While a significant part of this trend can be explained by the increasing popularity of the freemium model which facilitates secondary revenue streams in the form of in-app purchases and in-app advertising, it should be noted that past studies have shown that consumers have lower willingness-to-pay for the freemium model (Rietveld, 2017), as well as for apps that include advertisements (Ghose and Han, 2014). Moreover, our findings show that marketing-related costs increased substantially. Our data show that the average costs of obtaining a loyal app user (users who open an app three times or more)

\(^{10}\) Reported prices exclude game applications as digital games disproportionally operate the freemium model. Average prices including games come down to $2.72 USD for 2009 and $1.00 USD for 2016.
increased by 141% from 2011 to 2015: In 2011 app developers spent approximately $1.39 USD to acquire a loyal user, whereas in 2015 the average cost rose to $3.35 USD.

--- INSERT FIGURE 5 HERE ---

We find similar indicators in our other cases. One of the most telling signals illustrating the challenge to profit from complements is Kiva. The platform reports profitability rates (as measured by return on assets) for Field Partners over time. Analyzing this metric shows that Field Partners’ average profitability rates decreased by 940% from 2010 to 2014, to the point where many Field Partners were incurring losses later in the platform’s evolution. While we cannot unambiguously identify the source of this value slippage (Lepak, Smith and Taylor, 2007), we notice in some of our other cases that value is increasingly ceded to the platform sponsor. For example, in 2006 the average paid game by Steam’s platform sponsor Valve had 13.57 times as many downloads as a typical paid game by a third-party game developer, while in 2012 this multiple had grown to 56.42. In sum, we propose as third proposition:

**Proposition 3:** As platforms evolve over time it becomes increasingly difficult for complementors to capture value from their innovations.

**The moderating role of the platform sponsor’s orientation towards value appropriation**

Finally, the trends we documented in our first three propositions are less pronounced on Kiva and, to some extent, Kickstarter. We attribute this unanticipated finding to the differences in the platform sponsor’s stakeholder orientation: Apple’s directors are legally bound to the fiduciary
duty they have towards Apple shareholders to maximize firm value; Valve directors are bound by the fiduciary duties of care and loyalty, but not by the duty to maximize value for an anonymous owner; Kickstarter is a for-profit organization but with a public benefit exemption; and, Kiva is wholly not-for-profit. Put differently, we conjecture that the effects of platform evolution on complementor competition are amplified in ecosystems operated by platform sponsors with a greater overall orientation towards value appropriation.

While it is a non-trivial task to isolate such cross-platform variation, we do observe suggestive evidence for our conjecture: first, we note that Kiva enacted fewer governance changes during the course of our data collection period, and the policies implemented by Kiva generally favored Field Partners; second, the success rate of complements on Kiva, and to lesser extent on Kickstarter, is generally high as many loans and projects manage to reach their funding goals; third, the increasing skew in the demand distribution for loans on Kiva, and to lesser extent for projects on Kickstarter, is lower than for games on Steam; fourth, we are not convinced that these observations are solely driven by platforms’ market share. While we fully agree that market share affects platforms’ ability to exert power over complementors, both Kiva and Kickstarter are market leaders in their respective industries. Therefore, we propose:

**Proposition 4:** *The effects of platform evolution on complementors are moderated by the platform sponsor’s orientation towards value appropriation, such that the negative effects on the demand for complements, the evenness of the distribution of the demand for complements, and the value captured by complementors are amplified in ecosystems operated by platform sponsors with a greater orientation towards capturing value.*
CONTRIBUTIONS, LIMITATIONS AND FUTURE RESEARCH

Several scholars have recently suggested that to better understand platform ecosystems an evolutionary perspective is needed (McIntyre and Srinivasan, 2017; Tiwana et al., 2010, Tiwana, 2015a). Some have suggested to consider platform ecosystems as autonomously evolving meta-organizations (Gawer, 2014). Heeding these calls, in this paper we identified three evolutionary dynamics and explored how these factors affect competitive dynamics for complementors. Our analysis of four paradigmatic digital platform ecosystems suggests that, as platforms evolve over time, the average demand per complement decreases while the demand distribution becomes progressively skewed. A decreasing share of the complement population thus accounts for an increasing share of overall demand. We also find that it becomes increasingly difficult for complementors to capture value from their innovations as platforms evolve, as average prices fall and (marketing) costs increase. While these dynamics are shared by all four cases, they are more prominent for platforms in which the sponsor pursues value appropriation more aggressively. Our last finding is therefore that the effects of platform evolution on complementor competition are moderated by the propensity of the platform sponsor to capture value.

Our study harbors three contributions. First, by developing an integrative framework of platform evolution, we further our understanding of how platform ecosystems evolve. Integrating demand-side and complementor-side evolutionary dynamics into a single platform-level framework, we move beyond isolated accounts focusing on competitive crowding (Boudreau, 2012; Boudreau and Jeppesen, 2015) or demand heterogeneity (Gupta et al., 1999; Rietveld and Eggers, 2017). Additionally, we deliberately put platform sponsors’ governance interventions at the heart of our framework. By documenting the effects of governance changes, our work
extends previous studies pointing to the importance of platform governance in creating and capturing value (Boudreau and Hagiu, 2009; Eisenmann et al., 2009; Schilling, 2009), and prior empirical accounts of platform governance (Wareham et al., 2014). All cases show that following platform launch, governance frameworks are geared towards supporting complements producers, either by facilitating novel business models or by lowering barriers to platform entry. Later on in the platform lifecycle, however, the platform’s focus shifts towards facilitating end-users, lowering their search costs by curating digital storefronts and incorporating product feedback such as user reviews. These observations warrant further research, as we still know relatively little about governance frameworks in the context of the platform lifecycle.

Second, we respond to recent calls for research on competition within rather than between platforms (Gawer and Cusumano, 2014; Jacobides et al., 2017; McIntyre and Srinivasan, 2017). Complements producers vastly outnumber platform sponsors and they create a significant share of the ecosystem’s overall value. By studying multiple outcomes of complementor competition in different industry settings, our work builds on studies by Kapoor and Agarwal (2017), and Rietveld and Eggers (2017), and adds nuance to our current understanding of network externalities in digital platform ecosystems. We specifically show that the benefits of a growing user base will not be distributed uniformly across complements producers, due to increasing skew in the demand for complements. In addition to the shifting composition of the installed base (i.e., a growing number of late platform adopters) and the effects of competitive crowding (i.e., a growing number of complements producers), we propose platforms’ redistributive governance strategies and increased bargaining power as an additional explanatory mechanism.

Third, our framework also has practical implications for entrepreneurs entering or active as complementors in platform ecosystems (Nambisan and Baron, 2013). Our propositions offer
guidance in terms of which platforms to enter, and when. The likelihood of complementors capturing value is higher during the early phases of a platform’s evolution. Not only are average success rates higher when the platform market is nascent, but previous work by Boudreau (2012) and Rietveld and Eggers (2017) suggests that there may be important benefits in the form of real options by entering early (McGrath, 1999). In light of our findings, these may entail cultivating favorable relationships with the platform sponsor or building a community of loyal consumers. Later entrants will more likely face highly skewed demand distributions and will have to adjust their strategies accordingly. The increasing superstar dynamics in digital platform markets imply that complementors have to “go big or go home” and invest in Teecian complementary assets (also see Broekhuizen, Lampel, and Rietveld, 2013). In sum, complementors must carefully weigh the evolutionary state of the platform, as well as the platform sponsor’s system-level strategic objectives (Gulati et al., 2012), when considering platform entry.

Our study has several limitations with implications for future research. First, our research design prevents us from making any causal inferences. While we are certain that the documented relationships are anything but spurious, additional research is needed to better understand which of the evolutionary dynamics are causally driving our observed outcomes. We also encourage researchers to more systematically explore the role of cross-platform variation on evolutionary dynamics. Our work adds to what currently is a very small body of studies analyzing platforms in multiple contexts (Schilling, 1998; Stremersch et al. 2007) and more work is needed in this regard. A second limitation is our focus on platforms that are dominant in their respective industries. While this is a conscious decision, we expect certain evolutionary dynamics to play out differently for platforms lacking substantial market share and for new platform entrants facing well-established incumbents (see also Suarez and Kirtley, 2012). Shifts in a platform’s
governance framework and bargaining power are not only dependent on the participation of different user groups, but also on its position in the market in which it competes. Lastly, a complicating factor is that it is impossible to accurately pinpoint how far our platforms have progressed in the product lifecycle. Historically, platform lifecycles were well defined, especially in the pre-digital era when hardware came preloaded with fixed firmware. In the digital era, however, platform sponsors leverage the modular nature of software as demonstrated by our four cases, whose platform infrastructures are continuously altered, upgraded, and revised.

Further suggestions for future research are plentiful and include developing a better understanding of why complementors decide to enter platforms, studying the consequences of governance changes for complementors, unpacking the dynamic interplay between inter- and intra-platform competition, and creating a more detailed understanding of complementor strategies. One issue that particularly requires unpacking concerns developing a better understanding of how the evolutionary trajectories of digital platforms differ from traditional industries or products. Platforms are hybrid organizational forms, offering products and facilitating marketplaces in which others can compete. This complicates the application of traditional evolutionary theories. For example, while we observe some analogies with established theories of industry evolution (e.g., early mover advantages, falling prices), other stylized facts (e.g., shake-outs, declining entry rates) do not apply. The same can be said of product lifecycle theory. While this body of work largely applies to platforms as products, it does not take into account the contingent support of third parties in estimating platforms’ growth trajectories. Finally, industry architecture theory seems to apply predominantly where it pertains the role of the platform sponsor in orchestrating the ecosystem’s architecture and its subsequent effects on
complementors. Moving forward, the development of novel theory explicating how these bodies of work overlap and what makes each of them unique will be invaluable.

REFERENCES
Boudreau, K. J. (2010). Open platform strategies and innovation: Granting access vs. devolving control. Management Science, 56(10), 1849-1872.


## TABLES AND FIGURES

### Table 1. Overview of cases and data sources

<table>
<thead>
<tr>
<th>Platform ecosystem</th>
<th>Industry</th>
<th>Platform sponsor</th>
<th>Firm type</th>
<th>Founded</th>
<th>Complementors (complements)</th>
<th>Data collection period</th>
<th>Data sources</th>
</tr>
</thead>
<tbody>
<tr>
<td>iOS App Store</td>
<td>Mobile applications</td>
<td>Apple</td>
<td>Public</td>
<td>2008</td>
<td>Apps developers (mobile applications)</td>
<td>Jul-’08 - Dec-’16</td>
<td>Apple, PocketGamer.Biz, Fiksu, App Annie, secondary online sources</td>
</tr>
<tr>
<td>Kickstarter</td>
<td>Crowdfunding</td>
<td>Kickstarter</td>
<td>Public-benefit</td>
<td>2009</td>
<td>Project creators (creative projects)</td>
<td>Aug-’12 - Aug-’17</td>
<td>Kickstarter, Internet Archive (Wayback Machine), secondary online sources</td>
</tr>
<tr>
<td>Kiva</td>
<td>Microfinance</td>
<td>Kiva.org</td>
<td>Non-profit</td>
<td>2005</td>
<td>Field partners (small loans)</td>
<td>Apr-’05 - Dec-’14</td>
<td>Kiva, Kiva API, Internet Archive (Wayback Machine), secondary online data</td>
</tr>
<tr>
<td>Steam</td>
<td>Digital PC games</td>
<td>Valve</td>
<td>Private</td>
<td>2005</td>
<td>Game developer (digital games)</td>
<td>Jan-’05 - Dec-’16</td>
<td>Steam, SteamSpy, secondary online sources</td>
</tr>
</tbody>
</table>

*Note: cases listed in alphabetical order.*
Figure 1. Platform ecosystem conceptualization

PLATформ ECOSYSTEM

PLATFORM SPONSOR

COMPLEMENTORS

END-USERS

Same-side network externalities

Cross-side network externalities

Enable transactions, Govern interactions

Enable transactions, Govern interactions

Same-side network externalities
Figure 2. An integrative framework of platform ecosystem evolution

Platform ecosystem evolution

- **Platform-level dynamics**
  - Bargaining power (+)
  - Governance enactment (+)

- **Demand-side dynamics**
  - Demand heterogeneity (+)
  - End-user base (+)

- **Complementor dynamics**
  - Complementor entry (+)
  - Stock of complements (+)

Complementor competition

- Average demand per complement (p1)
- Evenness of distribution of demand for complements (p2)
- Value capture by complementors (p3)
- Value appropriation by platform sponsor (p4)
Figure 3. Number of Kickstarter projects launched and average success rate by month

Figure 4. Distribution of paid Steam game downloads by popularity rank and year

Figure 5. Distribution of prices of iOS App Store apps by year
### Appendix table 1. Demand and supply-side evolution by case

<table>
<thead>
<tr>
<th>Years from launch</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>iOS App Store (2008)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>iOS device owners (mln)</td>
<td>13.2</td>
<td>33.75</td>
<td>81.2</td>
<td>178.89</td>
<td>362.24</td>
<td>583.54</td>
<td>820.75</td>
<td>1106.82</td>
<td>1364.29</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>App developers (active apps)</td>
<td>23,000</td>
<td>55,000</td>
<td>110,000</td>
<td>150,000</td>
<td>180,000</td>
<td>282,000</td>
<td>400,000</td>
<td>494,000</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Kickstarter (2009)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Backers making pledges (repeat backers)</td>
<td>591,773</td>
<td>1,014,242</td>
<td>2,241,475</td>
<td>2,515,626</td>
<td>2,226,002</td>
<td>2,457,451</td>
<td>2,092,825</td>
<td>1,300,000³</td>
<td>2000</td>
<td>11,130</td>
<td>27,086</td>
<td>37,171</td>
</tr>
<tr>
<td>Projects launched</td>
<td>2,000</td>
<td>11,130</td>
<td>27,086</td>
<td>37,171</td>
<td>50,171</td>
<td>69,254</td>
<td>77,949</td>
<td>51,961</td>
<td>36,078</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Kiva (2005)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lenders making loans (first time lenders)</td>
<td>203</td>
<td>32,528</td>
<td>312,021</td>
<td>748,707</td>
<td>1,304,990</td>
<td>1,641,789</td>
<td>2,186,249</td>
<td>3,555,598</td>
<td>3,820,021</td>
<td>3,985,129</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Field partners active (loans posted)</td>
<td>1</td>
<td>26</td>
<td>78</td>
<td>92</td>
<td>103</td>
<td>123</td>
<td>138</td>
<td>173</td>
<td>224</td>
<td>262</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Steam (2005)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>User accounts (mln)</td>
<td>13</td>
<td>20</td>
<td>25</td>
<td>30</td>
<td>40</td>
<td>50</td>
<td>75</td>
<td>100</td>
<td>125</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Game developers (games released)</td>
<td>6</td>
<td>25</td>
<td>41</td>
<td>89</td>
<td>165</td>
<td>239</td>
<td>328</td>
<td>462</td>
<td>674</td>
<td>1,401</td>
<td>2,905</td>
<td>5,455</td>
</tr>
</tbody>
</table>

Notes: Reported statistics for iOS App Store and Steam are cumulative whereas those for Kickstarter and Kiva are incremental (yearly). This is done due to the strict time constraints on complements’ lifecycles on Kickstarter (projects) and on Kiva (loans) compared to the unrestrained lifecycles of complements on the App Store (apps) and on Steam (games). ³The last year of data on Kickstarter (2017) contains only eight monthly observations due to our data collection period.
## Appendix table 2. Overview of governance changes by case

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Allow for in-app purchases</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Allow for in-app advertising</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Shorten maximum project length from 90 to 60 days to improve projects’ average success</td>
<td></td>
<td></td>
<td>Lower entry barriers for developers by introducing Steamworks</td>
</tr>
<tr>
<td>4</td>
<td>Implement minimum criteria for project description and rewards system, creators must state projects’ risks and challenges</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Implement matching through Editor’s Choice, Top Charts, Free App of the Week, and Genius</td>
<td></td>
<td>Let lenders cover field partners’ currency exchange-related losses, if greater than 25%</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Enable user reviews for apps</td>
<td>Automatize entry screening for projects with Launch Now</td>
<td>Ease criteria for loans qualifying as “delinquent”</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Offer EU users 14 days refunds on app purchases</td>
<td>Implement matching through Social Performance Badges</td>
<td>Lower currency exchange-related loss boundary to 10%</td>
<td>Allow for in-game purchases</td>
</tr>
<tr>
<td>8</td>
<td>Search algorithm optimization improving matching apps to users</td>
<td>Implement matching through Projects We Like</td>
<td></td>
<td>Lower entry barriers for developers by introducing Greenlight</td>
</tr>
<tr>
<td>9</td>
<td>Introduce Search Ads</td>
<td></td>
<td></td>
<td>Enable user reviews and (up/down) voting for games</td>
</tr>
<tr>
<td>10</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>Store front re-organization (Discovery Update I) to improve matching of games to users</td>
</tr>
<tr>
<td>11</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>Offer users refunds on any purchase used less than two hours</td>
</tr>
<tr>
<td>12</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>Store front re-organization (Discovery Update II) to improve matching of games to users</td>
</tr>
</tbody>
</table>

*Note: "-" indicates outside of our data collection period.*