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What Drives Shifts in Platform Boundaries: An Organizational Perspective

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Abstract

Platform leaders often shift their platform's technological and organizational boundaries, but there has been little theoretical development on why and how this happens. Most platform research has been hitherto drawn from a limited set of theoretical perspectives (industrial economics and engineering design), which have conceptualized platforms as static. This article shows that by tapping into the rich literature on organizations and organizational boundaries, there are additional insights to be gained on the drivers of platform boundaries shifts.

Specifically, I draw on four distinct theoretical perspectives on organizations and their boundaries (efficiency, power, competence, and identity) to develop a set of propositions on the various factors that drive platform leaders to shift their platform boundaries. These propositions recognize yet go further than the well-established efficiency-seeking rationale for shifting platform boundaries. In addition to efficiency objectives, platform boundaries also get shifted in order to extend platform leaders' power over members of the platform ecosystem, be they rivals or complementors. Furthermore, platform leaders also shift their platform's boundaries in order to alter their own as well as complementors' capabilities to innovate. And under some circumstances, when seeking to increase their legitimacy as benevolent ecosystem custodians, platform leaders sometimes choose to refrain from shifting the platform boundary.

Taken together, these propositions suggest that platform leaders shift platform boundaries both for competition and innovation reasons. The paper concludes with a discussion of the important role that platform boundary decisions play in the competitive and innovation dynamics of platform-based ecosystems, and indicates avenues for further research.

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1. Introduction

Technological platforms such as Google, Apple, or Facebook have risen in recent years to such prominence in the global economy that they have stimulated a rapidly growing body of scholarly research (Rochet and Tirole, 2003 & 2006; Gawer, 2009; Eisenmann et al., 2011; Bresnahan and Greenstein, 2014) on platform competition and platform innovation.

Identified as a key feature of the global organization of digital innovation (Yoo et al., 2012), the platform as an industrial organization (Gawer, 2014) facilitates the stimulation, exploration and exploitation of complementary innovations generated by a vast pool of innovators worldwide (Baldwin and Von Hippel, 2011). Platforms constitute the technological foundation or building-block at the heart of "innovation ecosystems" (Adner and Kapoor, 2010; Nambisan and Sawhney, 2011; Wareham et al., 2014) or "ecologies of complex innovation" (Dougherty and Dunne, 2011). Within these ecosystems, central firms named "platform leaders" (Gawer and Cusumano, 2002), "keystone firms" (Iansiti and Levien, 2004), or "hubs" (Dhanaraj and Parkhe, 2006) often provide essential technologies as well as play an orchestrating role of driving ecosystem innovation.

Despite the importance of technological platforms, and despite the growing body of platform research, we still understand poorly how platforms evolve. In particular, there has been very little theorizing on what drives platform leaders to shift their platform boundaries. This may be because until recently, platform research has been dominated by two distinct theoretical perspectives, one from economics, and the other from engineering design, both of which have tended to conceptualize platforms as static. These differing perspectives, which until recently had not been integrated (Gawer, 2014), had conceptualized platforms either as types of markets ("two-sided markets", Rochet and Tirole, 2003; Evans, 2003: Armstrong; 2006) or as modular technological architectures (Baldwin and Woodard, 2009; Meyer and Lehnerd, 1997; Krishnan and Gupta, 2001; Jiao et al., 2005). These distinct theories have

tended to focus on the different directional forces platforms respond to. While the economic perspective has focused on platform competition, the engineering design perspective has focused on platform innovation. But none of these perspectives informs us on how platforms are likely to evolve over time, and in particular on the factors that drive platform leaders to deliberately evolve their platform.

This is an important problem, as in reality, platforms evolve constantly. Specifically, one of the important observable ways in which platforms evolve is when platform leaders deliberately alter or shift the platform boundaries. For example, Apple has recently entered mobile payment with Apple Pay, Twitter added a "buy" button and Google has serially expanded its internet search platform by including online payment (Google Checkout), productivity software (Google Docs), web browser software (Chrome), and mobile operating systems (Android). Facebook too has serially expanded, from allowing users to connect to others, to as allowing them to share their personal photos and videos, into let users take their identities and social connections with them as they move around the Web.

The question of what causes platform leaders to shift the platform boundaries has only recently begun to attract scholarly attention. For example, Eisenmann et al. (2011) in their study of "platform envelopment" discuss some of the factors that may drive platform scope's expansion in the context of platform competition. But deliberate scope expansion is only one of the ways in which platforms evolve, and competitive interaction is not the only driver of platform boundary shifts. Such shifts are also associated with increased industrial innovation, as Boudreau (2010 & 2012) shows in his studies on how "opening up" a platform's interfaces triggers innovation by complementors. But there has been so far no systematic exploration of the variety of factors that drive platform leaders to shift platform boundaries. This article aims to make progress on this question.

As discussed above, most platform research has hitherto been drawn from a limited set of theoretical perspectives, namely industrial economics and engineering design, which have either taken platforms as static, or have conceptualized them in narrow ways. This article shows that by tapping into the rich literature on organizations and organizational boundaries, there are additional insights to be gained on the drivers of platform boundaries shifts.

Specifically, I draw on four distinct theoretical perspectives on organizations and their boundaries (efficiency, power, competence, and identity) to develop a set of propositions on the various factors that drive platform leaders to shift their platform boundaries. In conjunction with the development of the theoretical argument, I use a set of illustrative examples to motivate and guide proposition development.

Taken together, these propositions recognize yet go further than the well-established efficiency-seeking rationale for shifting platform boundaries. In addition to efficiency objectives, platform boundaries also get shifted in order to extend platform leaders' power over members of the platform ecosystem, be they rivals or complementors. Furthermore, platform leaders also shift their platform's boundaries in order to alter their own as well as complementors' capabilities to innovate. And under some circumstances, when eager to increase their legitimacy as benevolent custodians of the platform ecosystem, platform leaders sometimes choose to refrain from shifting the platform boundary.

The paper concludes with a discussion of the important role that platform boundaries decisions play in the competitive and innovation dynamics of platform-based ecosystems, and indicates avenues for further research.

2. What are platforms? A literature review

The literature on platforms has developed in parallel in engineering design and economics, without, until recently, much cross-fertilization. While the economic perspective interprets platforms as facilitators of exchange or transactions between groups that could not otherwise

transact, and that are subject to network effects (Rochet and Tirole, 2003 & 2006; Evans et al., 2006), the engineering-design perspective (Jiao et al., 2007; Krishnan and Gupta, 2001; Meyer and Lehnerd, 1997) views product platforms as technological designs that help firms generate modular product innovation. Key examples in recent contributions, however, have been strikingly similar across these streams, and include Google, Facebook, Amazon, and Apple. More recently, scholars have begun to bridge these two streams by working toward a "unified view" (Baldwin and Woodard, 2009) or "integrative framework" (Gawer, 2014). And, recent work (Anderson et al. 2014; Boudreau, 2010, 2012; Ceccagnoli et al. 2012; Eisenmann, Parker and Van Alstyne, 2011) uses operationalizations of platforms that are consistent with both the economics and the engineering-design view.

2.1. The economic perspective on platforms

In the economics view, platforms are seen as special kinds of markets that facilitate exchange by allowing direct transactions between different types of consumers who could not otherwise transact. In this view, platforms have been variously referred to as "two-sided markets", "multi-sided markets", or "multi-sided platforms" (MSPs) (Armstrong, 2006; Evans and Schmalensee, 2008; Evans, 2003; Rochet and Tirole, 2003, 2006; Rysman, 2009). Network effects between the "two sides" of the market are seen as central in this tradition – so much so that Rysman (2009: 127) states that "in a technical sense, the literature on two-sided markets could be seen as a subset of the literature on network effects". In the economics-based research, with its focus on network effects, the multi-sided structure of a market is seen as exogenous and fixed. Research documents the self-reinforcing feedback loop that magnifies incumbents' early advantages, and strong network effects can, under certain conditions, drive competition between platforms to a "winner takes all" outcome (Eisenmann, Parker and Van Alstyne, 2005).

The economic perspective on platforms rests on strong (and often implicit) assumptions that are problematic as one begins to explore the issue of platform boundaries and the question of the drivers of their evolution. One main limitation is that, in all economic models, platform boundaries are indistinguishable from market boundaries, and crucially, in most economic models of two-sided markets, these boundaries are taken to be both exogenous and fixed. As such, these models do not offer much insight into what determines the boundaries of the platform and how or why they would evolve.[1]

2.2. The engineering design perspective on platforms

By contrast, in the engineering-design stream, platforms are technological designs of product architectures (Ulrich, 1995) that help firms develop product families (Sanderson and Uzumeri, 1995) and innovate more quickly and systematically by re-using common assets (Krishnan and Gupta, 2001). These studies developed the construct of platforms by exploring the innovation implications of the concept of "design hierarchy" (Clark, 1985) on methods of product development and production.

Baldwin and Woodard (2009: 24) characterize platforms as a special kind of modular architecture (Ulrich, 1995; Langlois and Robertson, 1992; Baldwin and Clark, 2000; Schilling, 2000), one that is structured around a core and a periphery. Platform interfaces play a crucial role in platform design and innovation. In any modular architecture, interfaces between modules indicate "how the various modules interact between each other and within with the larger system" (Baldwin and Clark, 2000). Baldwin (2008) develop further the notion of physical interface between modules as embodiments of the division of labour between different teams. The interface is therefore a divider (of labour between distinct teams), but also a connector, and a conduit of selected information facilitating

[1] For an important exception, see Eisenmann et al. (2011), as further developed in the next section.

interconnection. We shall return later to the importance of interfaces as one of the platform boundary.

Innovation is facilitated by modular architectures, in that they allow and enforce a specialization and division of innovative labour. They facilitate not only autonomous innovation within modules, but also mix-and-match innovation through innovative recombination of modules (Simon, 1962; Parnas, 1972; Langlois, 2002; Garud and Kumaraswamy, 1995).

This facilitation of innovation can happen within the firm, but also at the industry level, depending on how open the interfaces between modules are. The concept of "open" interfaces can be a fuzzy one (West, 2007) but the commonly understood meaning of an open interface is that the interface contains information that is accessible to external agents and usable by them to allow to build complementary innovation that is compatible with this interface. In the context of platforms, opening a system to complementary development affects innovation by drawing on a wider set of accessible external capabilities and distributed heterogeneous knowledge (Chesbrough, 2003), as well as independent experimentation (Langlois and Robertson, 1992).

In summary, the engineering view interprets platforms as purposefully designed technological architectures (including interfaces) that facilitate innovation. This view says that the design and use of platforms helps firms achieve economies of scope in production and design – allowing for economies of scope in innovation.

While useful to understand how platforms stimulate innovation, and in particular how open interfaces stimulate industry-wide innovation, the engineering design perspective on platforms has several important limitations. This perspective sees essentially platforms as structurally stable: innovation happens on modules, within stable system architectures, and facilitated by stable interfaces; this view therefore does not help explain how platforms

themselves evolve (that is, how what Baldwin and Woodard (2009) would call the "core", evolves). It is therefore difficult to develop a theory of platform boundary shifts solely based on this literature.

2.3. Recent advances in platform research: dynamic and integrative approaches

Industry platforms and ecosystem innovation

Moving beyond the traditional view of platforms as within-firms designs used to facilitate innovation on product families, technological platforms have been increasingly found to operate within larger networks of firms that are not necessarily linked through buyer-supplier relationships – also known as "innovation ecosystems" (Adner and Kapoor, 2010; Nambisan and Sawhney, 2011) or "ecologies of complex innovation" (Dougherty and Dunne, 2011. Within these contexts, Gawer and Cusumano (2002) defined the construct of "platform leader", a similar concept to an innovation ecosystem "keystone firm" (Iansiti and Levien, 2004) which orchestrate industry innovation. Gawer (2009: 2, 54) defined industry platforms as '...a building block, providing an essential function to a technological system – which acts as a foundation upon which other firms, loosely organized in innovation ecosystems, can develop complementary products, technologies or services'. For industry platforms within ecosystems, the sources of innovation are not restricted to within the focal firm or within focal firm's pool of suppliers. Instead, innovators could be anyone, and may be found anywhere, and the platform leader may not know ex-ante who or where innovators may be. In fact, an interesting specificity of industry platforms is that an industry platform leader does not need to know ex-ante who a complementary innovator might be. As in the case of Google's Android operating system or Apple's iPhone, potential innovators of complementary products self-identify to the platform leader, and can utilize the codified information on platform connectors (such as Application Programming Interfaces – APIs[2])

[2] An application programming interface (API) is defined by the Software Engineering Institute as: a technology that facilitates exchanging messages or data between two or more different software applications. ("Application Programming

and programming tools that are disclosed by platform leaders to build compatible complements. Industry platforms therefore reduce the platform leader's search cost for complementary innovators and extend the pool of accessible innovative capabilities that will indirectly create value for the platform (Gawer and Cusumano, 2013).

Platforms: From static to dynamic conceptions

As established above, the economics literature and the engineering design literature on platforms have largely developed without much cross-fertilization. Further, both the engineering design and the economics views mostly assume platforms to be static. In recent developments however, research has begun to address the question of platform dynamics. Research by Boudreau (2010, 2012) and Eisenmann et al. (2009, 2011) present some of the most advanced attempts in this area. For example, Eisenmann et al. (2009), in their essay on "opening platforms", while inscribing themselves in the two-sided markets literature, begin to tweak the platform-as-double-sided-market concept in a way that starts to bridge the supply and the demand perspectives on platforms. They call platforms "two-sided networks" and refer to "demand-side users" and "supply-side users". Eisenmann et al. (2011) is particularly interesting as it is one of the first papers to explicitly attempt to address platform evolution dynamics. The strategy that Eisenmann et al. (2011) focus on, which they call "platform envelopment", occurs in the context of competing platforms aiming at overcoming entry barriers. In this paper, the scope of the platform (as understood as the scope of the firm that is the platform leader) evolves over time. Envelopment entails entry by one platform provider into another's market by bundling its own platform functionality with that of the target's so as to leverage shared user relationships and common components. Platform envelopment

Interfaces," vol. 2004: Software Engineering Institute - Carnegie Mellon University, 2003). In other words, an API refers to a software interface that defines the service that one component, module, or application provides to others software elements. Generally invisible to end-users, APIs are carefully thought out pieces of code created by programmers for their applications that allow other applications to interact with their application.

happens for a variety of reasons: "shared user relationships", but also leveraging "common components".

Boudreau's (2012, 2012) articles are also important because they are among the first to combine explicitly competition and innovation in a longitudinal empirical platform study. Most interestingly, they examine how innovation and competition interact over time. Boudreau (2010) examines the evolution of complementary innovation associated with mobile handheld platforms over a period of 14 years. He finds that granting greater levels of access to platform complementors (in this case independent hardware developer firms) granted up to a five-fold acceleration in the rate of new handheld device development. Over time, he finds an inverted U-shape relationship between innovation and opening platform access, which is consistent with a hypothesis of "crowding out" of innovation incentives when competition among complementors increases beyond a certain level. Boudreau further confirms in his 2012 study of software applications to handheld mobile platforms the "crowding out" of innovation incentives due to high degree of competition between complementors themselves. Taken together, these important articles begin to identify drivers of platform boundary shifts. But there has been so far no systematic exploration of what drives platform boundaries shifts.

Platforms as organizations

Recent developments in platform research which propose an integrative framework bridging the differing perspectives of economics and engineering design, re-conceptualize platforms as organizations. For example, Gawer (2014) defines platforms as evolving organizations or meta-organizations that federate and coordinate their constitutive agents, these agents being capable of both competition and innovation, and which create value through harnessing economies of scope (in demand and/or in supply and innovation) thanks to their technological architecture that is modular and composed of a core and a periphery. This conceptualization

is consistent with recent research on innovation ecosystems (Adner and Kapoor, 2010), and on the impact of digitization on ecosystem innovation (Gawer and Cusumano, 2013; Yoo et al., 2012). Most promisingly for the purpose of this article, an organizational conceptualization of platforms creates the conceptual apparatus that allows us to break free of the static view of platforms that is pervasive in most of the economic and engineering design research, and holds the promise to yield insights on drivers of platform boundary shifts by drawing on the organizational literature.

3. What drives platforms boundaries shifts? Propositions development

One of the benefits of conceptualizing platforms as organizations is that we can attempt to apply insights from organizational research to the phenomenon of platforms. In this section I first clarify what platform boundaries are and I then turn to the task of applying organizational boundaries theories to develop propositions on why and how platform boundaries shift.

Once we conceptualize platforms as organizations (as in Gawer, 2014), one can make the further step to interpret platform boundaries as organizational boundaries. So far, there have been two different types of platform boundaries that have been examined in the platform literature: the first type of platform boundary is the scope of the platform (as in Eisenmann et al., 2011); the second is the platform technological interfaces (as in Boudreau, 2010 & 2012, and Baldwin & Woodard, 2009). I take the view to treat a platform's technological interface as a kind of organizational boundary because, as Baldwin (2008) and others indicates, these interfaces determine the modalities of engagement of external organizations with the focal platform.

In order to generate a set of propositions on what drives platform boundary shifts, I use Santos and Eisenhardt (2005)'s theorization on organizational boundaries. Santos and

Eisenhardt contend that different theoretical conceptions of organizations lead to different logics of how organizations set their boundaries. From this, I infer that various conceptions of organizations will lead to various drivers of platform boundary shifts. In their essay, Santos and Eisenhardt (2005) develop from various literatures four conceptions of organizational boundaries: efficiency, power, competence, and identity. Efficiency takes a legal-ownership view of atomistic boundary decisions based on transaction-cost logic. The power conception emphasizes the sphere of influence of the organization. The competence view focuses on the resource portfolio and its related configurations. And the identity view focuses on the often unconscious mindset by which organizational members understand "who we are". Santos and Eisenhardt (2005) explain that these conceptions are not necessarily competing but can be complementary. As this article does not aim to choose one conception of organizations over another, but rather aims to indicate avenues for future research stemming for an understanding of platforms as organizations, the broad yet rigorous approach of Santos and Eisenhardt (2005) provides an extremely useful and well-structured starting point.

3.1. Efficiency-driven platform boundaries

The efficiency view of organizational boundaries asks whether a transaction should be governed by a market or an organization. This conception is grounded in a legal understanding of organizations as governance mechanisms distinct from markets. The central argument is that boundaries should be set at the point that minimizes the cost of governing activities (Coase, 1937; Williiamson, 1985). In that view, boundary management is best understood as an accumulation of discrete decisions based on the criterion of governance cost minimization.

According to Santos and Eisenhardt (2005), the efficiency conception "implicitly assumes an established structure of economic activity, which translates into regular and recurrent transactions", which suggests that "the efficiency conception is most applicable in industry

characterized by intense price competition and stable structure" (2005: 493). This view is consistent with the economics view of platforms, where stable patterns of transactions exist between the two sides of the platform. This view is also consistent with the static view of platforms, and Baldwin (2008) in fact indicated that the location of interface between modules is both determined by, and a determinant of, low transaction costs: "Modularizations create new module boundaries with (relatively) low transaction costs. Modularizations thus make transactions feasible where they were previously impossible or very costly." (Baldwin, 2008: 187).

The efficiency conception yields propositions on what drives platform leaders to shift the boundary of the platform: within the economic vertical integration literature, research focusing on bundling and the multiproduct firm has examined entry in complementary markets (which is equivalent in our case to the platform leader moving the platform boundary outward), but with the exception of Farrell and Weiser (2003), it has not paid particular attention to platform dynamics or network effects (see for example Schmalensee, 1981; Panzar, 1989; Whinston, 1990; Nalebuff, 2004). These authors suggest that monopolists have several strong reasons for entering complementary markets to offer a bundle or a tie, some of them (but not all) being efficiency driven. Cournot (1838) showed that multiproduct firms internalize the demand externality across markets whereas single product firms do not, so that both consumer welfare and total profits are increased if both products are produced by a single firm. Economists have also identified non-efficiency driven reasons for platform expansion, as firms may also enter multiple markets to weaken rivals through price competition, driving the price of the complement down and raising the price of the essential good to capture the available rent (Ordover et al., 1985). I shall detail these dynamics in the power-driven boundaries section. All these models, however, ignore the effect of entry on complementors' incentives to innovate (Gawer and Henderson, 2007), which is only

justifiable if one either assumes a stable industry environment (as in, with no innovation), or if one assumes that the social welfare stemming from complementors' innovation would be inferior to the social welfare stemming from the monopolist's internalization of the demand externality across markets (reducing what is referred to as "double marginalization").

Some of the reasoning of Eisenmann et al. (2011) on the private economic benefits of platform envelopment stems from this bundling logic, and contains elements of both efficiency-driven platform boundary shifts, described here, as well as power-driven platform boundary shifts (these will be detailed in the next section). Eisenmann et al. (2011) propositions on platform envelopment are framed as competitive moves by platform leaders against other firms – and other markets are seen as "targets". Eisenmann et al. (2011) consider platform leader entry (framed as a "competitive attack") through bundling into markets that can be either complements, unrelated, or weak substitutes. This reasoning, following the bundling tradition, does not take into account the potential detrimental effects of "attack" on complementors' innovation incentives. "Through bundling", Eisenmann et al. (2011: 1275) explain, "a market entrant can foreclose a target's access to customers and thereby reduce the target's scale". Since platform markets engender economies of scale both through network effects and leveraging fixed costs, they are particularly good candidates for foreclosure attack (Whinston, 1990, Carlton and Waldman, 2005). Note how in this explanation the efficiency-argument ("economies of scale", "leveraging fixed costs") is put forth together with the power argument ("foreclosure"). But for the sake of conceptual clarity it is important to separate analytically the distinct drivers to platform envelopment.

Eisenmann et al (2011)'s argument depends crucially on whether the "target" market is a complement, a substitute, or unrelated. If the target market is a substitute, "the envelopment is most likely to succeed if the bundling offers significant economies of scope" (in production) (Eisenmann et al., 2011: 1281). If the target market is unrelated, the envelopment

is most likely to succeed "if user bases overlap significantly and when production economies of scope are high" (Eisenmann et al., 2011: 1282). And last, if the target market is a complement, "due to [modular] product designs that are optimized to reduce functional overlap, attackers who target complements will not normally realize significant [production] economies of scope. Consequently, the envelopment of complements is most likely to succeed with high overlap in platforms user bases" (Eisenmann et al., 2011: 1280). Note how the first two platform boundary moves (substitute or unrelated target market) respond mainly to production-efficiency logic, whereas the entry into a complementary market follows leveraging overlapping user base and through bundling foreclosing rivals access to the user base, which is not an efficiency argument, but a power argument. I shall develop further the argument about power-driven boundary moves in the next section.

I thus propose the following propositions regarding the conditions under which an outward shift of the platform boundary scope (i.e., a platform expansion into an adjacent market) would create efficiency-driven gain. Platform leaders will expand the scope of the platform under the circumstances detailed below (P1a, P1b) when they wish to win an efficiency-driven competitive gain: (a) over substitute producers (P1a); (b) over unrelated products, i.e. neither complements nor substitutes producers (P1b), as detailed below:

P1a: A platform leader will shift its boundary shift outward when there are high economies of scope in the production of the platform and substitute products.

P1b: A platform leader will shift the platform boundary outward in entering an unrelated product market, when there are both high economies of scope in the production of the platform, and a high overlap of the pla*tform's and the unrelated produc*t*'s user* bases.

3.2. Power and platform boundaries

The power view of organizations (Thomspon, 1967; Pfeffer and Salancik, 1978) "shifts the focus from the locus of transactions to the more expansive boundaries of control" (Santos and

Eisenhardt, 2005, 496). The power conception frames the organizational boundary as its sphere of influence. It suggests that influence over strategic relationships with key environmental actors will enhance organizational performance. The central argument is that organizational boundaries should be set at the point that maximizes strategic control over crucial external forces (Porter, 1980; Pfeffer and Salancik, 1978). Thus, a boundary decision is a choice of activity domains over which the organization will exert influence (Santos and Eisenhardt, 2005).

As explicitly identified by Santos and Eisenhardt (2005: 496), the power view of organizations is consistent with the role of platform owners as "platform leaders" (Gawer and Cusumano, 2002) who drive industry innovation beyond the scope of their firm in technological directions that are platform-enhancing through a variety of cross-industry influencing behaviours. The boundaries of the platform in this sense can be interpreted as the boundaries of the ecosystem within which the platform operates.

The power view of platform boundaries could be potentially yield important insights to the study of platforms, as the question of platforms' market dominance and potential power abuse has become a recurrent feature of platform industries. For example, successful industry platforms such as Microsoft and Google have accrued quasi-monopolistic power over their respective markets, and have been subjected to intense scrutiny and lawsuits by regulatory authorities. Platform boundaries are at the heart of these antitrust challenges and proposed remedies. For example, the US case against Microsoft rested on Microsoft's alleged abuse of power as reflected by the bundling (interpreted as "envelopment" by Eisenmann et al. (2011)) of Internet Explorer with Windows operating system. This shift in the boundary of the operating system platform resulted in a first remedy proposal that ordered a breaking up of Microsoft into two organizations (i.e., creating another organizational boundary). Meanwhile, the EU examined how streaming media technologies were integrated with Windows

examination of Microsoft bundling (another case of "envelopment") Windows Media Player with Windows operating system, demanding as remedy that Microsoft offers to consumer the choice to separate the two, by including a "choice screen" allowing users to use rival browsers. In this section on power-driven boundaries shifts, I develop about such shifts not only for the extreme case of monopolist firms, but also for firms that aim to maintain or expand market power in the context of imperfect markets' competitive dynamics. I shall turn first to shifts in platform boundary scope, and then to shifts to platform boundary openness.

Platform scope expansion

While we have seen in Sub-section 3.1 that platform scope expansion can happen for efficiency reasons, it can also happen purely to maintain or extend market power in the context of competitive rivalry. Continuing with Eisenmann et al (2011)'s predictions on platform envelopment, but now focusing specifically on market-power-driven boundary moves, these authors suggest that in the context of competitive rivalry between platforms, a platform owner can expand the scope of its platform in order to perform a so-called "cross-layer envelopment" (Eisenmann et al., 2009 and 2011). In order to explain this concept, consider modular industries: in such industry structures, reduced integration results in industries comprising of multiple layers, each with separate suppliers. As Eisenmann et al. (2009: 150) indicate: "friction over divided leadership is exacerbated as new layers with new leaders emerge". […] "Over time, dominant players typically emerge within layers that are subject to strong scale economies or network effects, which […] often vie with the focal platform for technical leadership (Bresnahan and Greenstein, 1999)". A platform can therefore absorb complements in order to extract a greater share of the industry rent. Returning to Eisenmann et al (2011), they suggest that if the target market is a complement, "due to [modular] product designs that are optimized to reduce functional overlap, attackers who target complements will not normally realize significant [production] economies of

scope. Consequently, the envelopment of complements is most likely to succeed with high overlap in platforms user bases" (Eisenmann et al., 2011: 1280). In ambiguous and/or dynamic environments, organizations may not only use boundaries defensively to protect existing positions, but also offensively to tip emergent markets in their favour (Ozcan and Eisenhardt, 2005). Consequently, a platform could expand in a complementary market to block such as "cross-layer envelopment" from former complementor-turned-rival. I therefore propose:

P2a: When seeking to maintain or increase its market power in the face of rivals, or when seeking to protect itself in the face of complementors-turning-into-rivals, a platform leader will choose to expand the platform boundary outward.

This proposition is consistent with research from industrial organization economics by Carlton and Waldman (2002) on the strategic use of "tying"[3] to preserve and create market power in evolving industries. Carlton and Waldman (2002), building on Whinston (1990), have shown that a monopolist, by tying a primary good in its initial market to a complementary good subject to network externalities in a newly emerging complementary market, can sustain its market power in its initial market, and that in addition it can also "swing" or transfer its initial monopoly to the newly emergent complementary market. Interestingly, Carlton and Waldman (2002) explain that that some ties can be achieved not only through contracts and pricing but also, as in the case of IBM in the 1970s, through product design[4]. Expanding the scope of a platform (including functionality B to a platform A) is a product design decision that can therefore be seen as an economic equivalent to tying, and Carlton and Waldman (2002) results apply. Expanding platform scope can be therefore a useful strategy to win non-efficiency-related gains by either foreclosing rivals or deterring entry by complementors which may turn into rivals.

[3] Tying consists in refusing to sell product A to a consumer unless the consumer also purchases product B.
[4] In the 1970s, there was an allegation against IBM that IBM's new central processing unit was interface incompatible with the plug-in components of rivals – a tie achieved through product design (Carlton and Waldman, 2002: 197).

Note that if the focal platform is not considered a monopolist, this proactive defensive move aimed at gaining market power is not considered anticompetitive. However, even if such moves may be considered lawful, expansionist moves from platform leader can trigger adverse effects such as reputation effects of a platform leader not hesitating to squeeze complementors' margins, thereby decreasing complementors' continued incentives to innovate on complements (Farrell and Katz, 2000; Gawer and Henderson, 2007). I thus propose the following:

P2b: A platform leaders will only shift outward the platform boundary after weighing the trade-offs between the benefits of increased efficiency and power stemming from platform expansion*, and the adverse effect on complementors' innovation incentives.*

Note that the success of this scope-expansion strategy assumes that the platform leader can perform a correct ex-ante estimate that the bad reputation effect stemming of "crushing complementors" will be negligible compared to the efficiency gains accrued thanks to the user bases overlap. In practice however, this is likely to be very difficult to achieve. In addition, it bears significant long-term risks, as if used systematically it creates a strong dinsincentives for complementors to continue to develop complements to the platform. Consider for example the enormous ill-will effect accruing against Microsoft in the early 2000s, which itself fuelled the development of an alternative operating system, Linux, backed up by virtually all Microsoft opponents, including IBM, as well as triggered regulatory scrutiny. This is therefore a short-term strategy, which may or may not be valuable depending on platform leaders' time-horizon of, as well as on their assessment of the likelihood of complementors joining an alternative existing or emerging platform. I shall return to the (negative) reputation effect due to this strategy in Section 4.4. on identity-driven boundaries.

Altering platform interface openness

Another expression of how altering platform boundaries can be interpreted as a struggle for power in the context of competitive rivalry can be found in examining cases in which platform leaders unilaterally change the degree of openness of their platforms external-facing technical interfaces. In particular, selectively closing platform boundaries is sometimes used as either a pre-emptive or retaliatory tactic against a former complementor –turning-into-rival. A well-known example concerns Apple's decision to selectively close its interface to Adobe's Flash player in 2010. At the time, Apple CEO Steve Jobs explained in a famous published letter, that one of the main reasons why Apply would selectively close its iPhone, iPad and iPod interfaces to Adobe's video player Flash was a refusal to become dependent (Jobs used the wording "at the mercy", a power-laden concept) upon a third-party "deciding if and when they will make our enhancements available to our developers", as it would "hinder the development and progress of the platform".[5] Another case in point is when Twitter changed its API in 2012, preventing users' Tweets from appearing on the rival social networking platform LinkedIn (previously perceived as a complementor), as an attempt to cease adding value to LinkedIn and therefore stop fuelling the growth of LinkedIn with Twitter content.[6]Closing the platform interface can therefore be used to weaken rivals in the context of growing competition from complementors.

P3: A platform leader who starts perceiving a complementor-turning-into-a rival as a competitive threat is likely to close the platform interface between the platform and this complementor, as this will stop fuelling the growth of that complementor and protect the platform from being displaced.

[5] Source: Steve Jobs, "Thoughts on Flash", 29 April 2010. http://www.apple.com/hotnews/thoughts-on-flash/ Steve Jobs revealed six main reasons behind Apple's position of why Apple would not support Flash. Besides claiming that Flash was closed and proprietary and had major technical drawbacks (reliability, security and performance, battery life and touchable devices), Jobs concludes with "the most important one": "Letting a third party layer of software come between the platform and the developer ultimately results in sub-*standard apps and hinders the enhancement and progress of the platform … We* cannot be at the mercy of a third party deciding if and when they will make our enhancements *available to our developers."*

[6] Source: http://linkedinprofileservice.co/linkedin-profile/linkedin-profiles/twitter-stops-no-longer-displays-tweets-on-linkedin-profiles/.

When platform leaders are seen as monopolists, their unilateral decisions to alter the openness of their platform interface are often challenged by firms that call on the regulator (through antitrust lawsuits) which often, but not always, interprets this as abuse of power. For example, the EU antitrust lawsuit against Microsoft started in 1998, triggered by Sun Microsystems' complaint about Microsoft's lack of disclosure of some of the interfaces to Windows NT. In a similar fashion, Intergraph raised in 1997 a complaint against Intel's refusing to disclose information about Intel's chip which Intergraph deemed an "essential facility". If the platform leader is a monopolist, unilaterally closing its interface to complementors can be assessed by the regulator as an anticompetitive way to restrict access to an essential resource.

It now becomes evident, considering the propositions developed in this section and the previous one, that both efficiency reasons and power reasons can lead to similar outcomes (such as platform expansion). This makes it hard to distinguish empirically between efficiency consideration and power-driven considerations when assessing the drivers of platform expansion. One of the vexing difficulties of antirust economic analysis is that it is empirically very difficult to assess whether platform boundary moves were conducted for efficiency reasons, or for monopolistic-power-abuse reasons. This ambiguity characterized much of the Microsoft lawsuit economic analysis, as Microsoft platform expansion moves was defended by Microsoft's proponents as efficiency-driven, while the opposition was claiming they were purely monopoly-extending moves.

3.3. Competence-based view of platform boundaries

The competence view (Penrose, 1959; Chandler, 1977; Wernerfelt, 1991; Barney 1991) sees organizations as unique bundles of resources. In this view, the organizational boundary is dynamically determined by matching organizational resources with environmental opportunities that are both attractive and amenable to the organization's using its resources to

gain competitive advantage. The boundary is therefore set at the point that maximizes the value of the firm's resource portfolio.

Santos and Eisenhardt (2005: 499) indicate that in technology-based ecosystems, competence and power view are "synergistic", meaning that "organizational actors use one boundary conception in a way that makes the use of another boundary conception more advantageous". They explain that in technology-based ecosystems, by definition, innovation and interdependence are critical, and that "resources can be deployed in complementary product/market domains to secure adoption of the focal organization's industry standard". This view seems particularly relevant to how platform leaders can set the platform boundary in such a way that they can maximize access to innovative resources from complementors. A case in point, highlighted by Santos and Eisenhardt (2005: 500) is the case of how Intel (Gawer and Cusumano, 2002) developed resources in markets such as chipsets that were complementary to Intel's main microprocessor market as well as defined interfaces, which helped increase Intel's power over complementors and buyers.

Applying the competence-based view to the case of platforms illuminates the fact that not only the developers can be used as resources by the platform, but also, consistent with the engineering view of platform as sets of re-usable components, technological elements of the platform itself can be used as a resource by external developers. Interestingly, Ghazawneh and Henfridsson (2012) indicate in a study of the Apple iPhone platform that the platform boundary itself can be construed as a resource, and they interpret the question of boundary design as crucial to solve the recurring tension between maintaining platform control and, at the same time, stimulating third-party developers' complementary applications.

The role of platform boundary as a resource is also visible in how Google develops and shares freely specific software code as open APIs (as of 2013, Google published 108 APIs

and kept doing more)[7] to encourage independent software developers to utilize Google numerous web services and incorporate them within their own, Google-complementary innovations. For example, there are APIs offered for almost all of Google's popular consumer products such as Google Maps, YouTube, and many others. In particular, the Google Data APIs allow programmers to create applications that read and write data from Google services. Currently, these include APIs for Google Apps, Google Analytics, Blogger, Google Base, Google Book Search, Google Calendar, Google Code Search, Google Earth, Google Spreadsheets, Google Notebook, and Picasa Web Albums. In the case of digital platforms, this is precisely the role that "open APIs" play: they are a key resource for developers. In summary, the more a platform leader aims to stimulate external innovation on complements, the more it will maintain the platform interfaces open. For the platform to have access to external developers (and derive value from their platform-compatible innovations), it has got first to allow external developers to access the platform resources, which requires the platform leader to open its interfaces. From this I infer:

P4: A platform leader will maintain open interfaces when it aims to stimulate modular innovation in complements yet lacks the competences to generate the innovation itself.

Google pushes the concept of platform boundary as resource to unprecedented levels. We have already seen that the platform can be a resource to developers, and that developers can be a resource for the platform. Through its APIs, Google has developed yet another a sophisticated way to utilize not only its own users' data, but also data about the usage and the usage context of non-Google-developed applications (ie, applications developed by external developer, as long as they use a Google API). Whenever an end-user uses such an application, Google, through its APIs, is able to capture and feed this end-user data into a

[7] Sources: https://developers.google.com/ and http://www.programmableweb.com

Google semantic database that is then used by Google to improve its own semantic organization of information, and hence the quality of Google's search engine.

Moving now to the conditions under which platforms will expand their boundary scope or close off their boundaries for competence-related reasons, I turn to highlighting the importance of firm-level system integration capabilities for internally-driven systemic innovation, -- which is a different kind of innovation than modular, externally-developed innovation. Brusoni et al. (2001) and Pavitt (2003) indicate the unevenness of rate of technical change between modules and the extent of uncertainty about interdependency between modules as major reasons why firms need to keep cultivating system integration capabilities, indicating that firms need to "know more than they make". Zirpoli and Becker (2011) suggest that system integrators should retain in-house integrating knowledge or risk being "hollowed-out".

In addition, recent organizational research on modularity and system integration has developed of a more nuanced view of the relationship between organization and product modularity (Brusoni and Prencipe, 2006; Cabigiosu and Camuffo, 2011; MacDuffie, 2013) than was originally described in the so-called popular "mirroring hypothesis" (Sanchez and Mahoney, 1996). In particular, the idea that that modular organizations mirror the modular technologies they build has in fact received mixed empirical evidence (see Colfer and Baldwin, 2010 for a review), as non-modular organizations that produce modular products were observed in the aircraft engine industry (Prencipe, 1997), hard disk industry (Chesbrough and Kusunoki, 2001) and the automotive industry (Takeishi, 2002). MacDuffie (2013) as well as Staudenmayer, Tripsas and Tucci (2005)'s empirical studies of the dynamic organization of modularity have highlighted that not only modularization is a process fraught with the perpetual emergence of inter-organizational interdependencies, despite efforts to limit them, but also the important role of integration processes or integration phases in how

modules evolve in new product development processes. Brusoni and Prencipe (2006), in their study of the joint evolution of the organization and product design, found that integration in the knowledge domain can enable effective modularization of the technological domain. Integration capabilities are therefore necessary to evolve even modular systems.

Complementing the bove, the literature on industry architecture (Jacobides et al., 2006; Jacobides and Winter, 2005; Jacobides and Billinger, 2006) indicates that firms are more likely to retain activities internally for which they possess superior capabilities, and that these choices of organizational scope have an effect on the evolution of capabilities as well, as organizations will strengthen capabilities for retained activities and weaken or lose capabilities for outsourced activities, thereby reinforcing, or changing, the industry's architecture. As Henderson & Clark (1990) and Brusoni, Prencipe & Pavitt (2001) have highlighted, different kinds of innovation are associated with different kinds of firms' capabilities: while some firms are more able to innovate on modules, others can better innovate on systems that require integration between modules ("systemic" innovation). This reasoning leads to a proposition on a resource-based view of platform boundary expansion:

P5: A platform leader will expand the platform scope when it wishes to exploit or develop its internal capability to create systemic or integrated, as opposed to modular, innovation.

Note that while P4 focused on modular innovation in complements, P5 concerns innovation requiring an integrating capability, in other words "systemic" innovation. An example of such a move can be found in Google's acquisition of Motorola Mobility, a mobile phone handset maker with mobile phone equipment hardware design and manufacturing capabilities complementing Google's software capabilities in mobile operating systems, as indicated by Motorola Mobility CEO announcement at the time: "We have shared a productive partnership with Google to advance the Android platform, and now through this combination we will be

able to do even more to innovate and deliver outstanding mobility solutions across our mobile devices and home businesses."[8]

3.4. Identity, legitimacy and platform boundaries

Organizational boundaries of identity are defined in the following way: "Focusing on how organizational members define the organization holistically, the identity conception asks who the organization is" (Santos and Eisenhardt, 2005: 500). In this perspective, organizations are conceptualized as social contexts for sensemaking (Weick, 1995). The central argument is that "organizational boundaries should be set to achieve coherence between the identity of the organization and its activities", with "boundary management then best understood as a process of resolving inconsistencies between identity and organizational activities and markets" (Santos and Eisenhardt, 2005: 500).

Gawer and Cusumano's (2002) early research on platform leadership highlighted that perceived legitimacy of the platform leader by its ecosystem members is a crucial variable for platform leaders to be able to exert a sustainable influence on their ecosystem members. Precisely because platform leaders often rise to a position of power due to network effects, the essential counterbalancing force lies in the governance of the ecosystem that is consistent with the promotion of the collective good of the ecosystem. This explains why the often projected identity of a platform leader is that of a neutral broker that aims to convince its ecosystem members that it sincerely has the interest of the ecosystem at heart. Principally, the identity of a legitimate platform leader needs to be consistent with deliberate refraining from power abuse.

Consistent with this insight about the importance of legitimacy for influence over the ecosystem, Garud et al. (2002) argue that formal legitimacy eluded Sun in its attempt to

[8] Sanjay Jha, CEO of Motorola Mobility, as cited in May 2012 in http://www.google.com/press/motorola/

sponsor Java and to "mobilize the [industry] bandwagon", despite a promising beginning and strong initial industry support. Garud et al. (2002) identify one main reason why Java failed to rally the industry as what they call a "legitimacy trap". They highlight that the standard sponsorship process created legitimacy challenges for Sun, as, in its attempt to sponsor the Java technology Sun attempted to play two roles: rule designer and rule enforcer. This resulted in a loss of credibility for Sun, who "wanted to play the referee, but … wanted to play in the game too" (Garud et al., 2002, p. 208).

Gawer and Henderson (2007), building on Farrell and Katz (2000), indicate that Intel paid critical attention to manage and sustain a reputation of benevolence vis-a-vis complementors, and that it was precisely in order to preserve this reputation of not abusing its power position and avoid being perceived as "crushing complementors" that it systematically refrained from entering a number of complementary markets. As Intel managers mention in Gawer and Cusumano (2002) and Gawer and Phillips (2013), it is of the utmost importance for platform leaders to appear "fair" and "trustworthy": "we have to be meticulously fair", as "trust [with the complementors] is the real challenge". Gawer and Phillips (2013)'s study of Intel suggests that in order for an organization to establish this kind of legitimacy, it also has to perform a kind of internal "institutional work" (Lawrence & Suddaby, 2006) on its own perception of its organizational identity, in order to preserve the coherence between its own organization's members' perception of its identity and the image it aims to project of its identity to the ecosystem members. In addition, as Intel attempted not only to adapt but also to shape the new platform logic in the computer field, it deliberately worked to legitimize new categories of collective identities (Wry et al., 2011) such as "complementors" and "platform leader", and, in parallel, it worked to establish its own legitimacy as a organization to be accepted by ecosystem members in this new kind of identity as a platform leader. Consistent with this pattern of platform leaders aiming to project their identity as benevolent

curators or custodians of the ecosystem, in the case of Apple, Steve Jobs wrote in his 2010 "Thoughts on Flash" public letter mentioned above: "We want to continually enhance the platform so developers can create even more amazing, powerful, fun and useful applications. Everyone wins – we sell more devices because we have the best apps, developers reach a wider and wider audience and customer base, and users are continually delighted by the best and broadest selection of apps on any platform. (Emphasis added).

In the case when a platform leader does expand in a complementary market, the problem of potential loss of legitimacy and credibility as a neutral broker becomes particularly acute. Google again provides another example of how platform leaders may in a case such as this one exert significant resources to attempt to maintain an external perception of legitimacy, even as it expanded its platform boundary. Relative to the recent case, already mentioned above, of when Google acquired Motorola Mobility in 2012, Google as of June 2013 still maintained a page on its website specifically dedicated to attempt to convince its ecosystem members (as well as the regulator) that this acquisition does not constitute an abuse of power, nor that it would be used by Google to create unfairness in the functioning of the ecosystem, and that it is "good for competition". In this page, titled "Facts about Google's acquisition of Motorola", and itself composed of several sections, one of them "Good for Competition", Google explicitly indicated: "What we aren't doing": "Closing the Android ecosystem; Favoring Motorola Mobility over other hardware manufacturers; Forcing partners to use Google Search".[9]

I interpret therefore the identity conception of platform boundaries as consistent with the proposition that for a platform leader to provide sustained incentives for it ecosystem innovators to develop complementary innovation to the platform, it has to establish a governance of the ecosystem that includes a shared set of explicit as well as implicit rules of

[9] Source: http://www.google.com/press/motorola/competition/).

collective-welfare- enhancing behaviours within a shared accepted set of collective identities (Wry, Lounsbury and Glynn, 2011). Appropriate ecosystem governance rules, supported by a platform leader whose actions are consistent with its organizational identity will creates conditions of ecosystem welfare and facilitate vibrant innovation ecosystems. This view is consistent with research by Boudreau and Hagiu (2009) who see platform leaders as a kind of regulator of their ecosystem, and Nambisan and Sawhney (2011) who see them as orchestrators of network-centric innovation. From this I infer:

P6: A platform leader will refrain from scope expansion when it perceives that the resulting legitimacy loss would outweigh the short-term competitive gains from such expansion.

Table 1 summarizes the six propositions detailed above.

INSERT TABLE 1 HERE

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4. Discussion and Conclusion

In this article, I have developed a set of propositions on the various factors that drive platform leaders to shift platform boundaries, using an organizational perspective on platforms, and examining platform boundaries shifts through the theoretical organizational lenses of efficiency, power, competence, and identity.

The propositions developed in this article recognize yet go further than the well-established efficiency-seeking rationale for shifting platform boundaries. In addition to efficiency objectives, platform leaders shift platform boundaries in order to extend their power over members of the platform ecosystem, be they rivals or complementors. Furthermore, platform leaders also shift their platform's boundaries in order to alter their own as well as complementors' capabilities to innovate. And under some circumstances, when eager to

increase their legitimacy as benevolent custodians of the platform ecosystem, platform leaders sometimes choose to refrain from shifting the platform boundary.

These results lend themselves the following discussion points.

Both innovation and competition drive platform boundaries shifts

Taken together, the propositions developed in this article suggest that both competition and innovation rationales drive platform leaders to shift their platform boundaries. Platform leaders shift platform boundaries either to stimulate industry innovation and/or to protect themselves from competition, and/or to increase their power in a competitive interaction. In general, the more open a platform's technological interfaces are, the greater the scope of external capabilities a platform can tap into in order to elicit external modular, platform-enhancing innovation. Closing off platform boundaries can in turn be validly interpreted as a platform leader's reactive or pre-emptive competitive move against complementors-turning-into-rivals, but it can also reflect a capability-development objective, with the aim to develop systemic innovation capabilities. In addition, for competitive reasons as well as for innovation reasons, platform leaders sometimes expand the scope of the platform. Platform scope expansion can be driven by efficiency efforts, as well as by systemic innovation capability building, but also by sheer power-seeking and even in some cases power abuse. Platform scope expansion can therefore have adverse effects by diminishing incentives for complementors to innovate.

Multiple possible drivers for similar platform boundary shifts

The analysis above suggests that similar observable platform boundary shifts could be attributed to different motives or logics: efficiency, power, competence, identity. This causal ambiguity is problematic for those, such as regulators, who may aim to assess whether dominant platform leaders' deliberate boundary shifts are efficiency-driven, welfare-enhancing, or purely market-power-driven. Precisely because platform leaders achieve high

levels of industry power and influence, platform boundary shifts will undoubtedly continue to be subject to intense scrutiny, from complementors, competitors, users, and regulators.

For researchers aiming to explore further how to distinguish empirically these different motives for platform expansion, this empirical difficulty constitutes a research opportunity. For practitioner observers and regulators, a possible way to clarify the ambiguity of platform boundary moves can be found in the insights stemming from the identity conception of organization. In effect, by highlighting the importance of the identity view, the paper underscores that platform boundary shifts are better interpreted alongside a longitudinal assessment of the governance of the platform's ecosystem. A potentially fruitful venue for observers to better interpret platform scope expansion could lie in widening the observation set, and observing not only how a platform leader alters the platform boundary over time, but also how it governs its ecosystem over time: this will provide a way to assess the extent to which the organizational identity of the platform leader is or not coherent with its actions, which will allow to deduce for example whether it might in the long-term interest of complementors to continue to be part or not of this platform's ecosystem.

Limitations and avenues for further research

While this article has clarified the different drivers of platform boundary shifts, an obvious limitation of the study is that the elemental platform boundary shifts I have identified constitute isolated stages, which are bound in reality to elicit strategic responses in what could be framed as multi-stage games. While it is outside the scope of this article to devise an exhaustive set of multi-stage responses, such a development would be a potentially fruitful direction for research, possibly using game theory methods or computer simulation methods.

In addition, several other research opportunities come into focus. An obvious further contribution to this conceptual analysis would be an empirical study testing the propositions presented here. Another logical development of this line of research would be to complement

this study of the drivers of platform boundary shifts by a study of the consequences of platform boundary shifts on ecosystem members' behaviours. From the analysis above, it would seem likely that platform leaders' shifting of platform boundaries shape platform-based ecosystem members' behaviours in three ways: (1) The shifts shape ecosystem members' incentives to decide whether to collaborate or to compete with the platform leader; (2) Platform boundary shifts affect complementors' incentives to innovate on platform-enhancing innovations; (3) And last, they also affect complementors' capabilities to innovate on complements. These propositions, once developed and empirically tested, would suggest that the strategic management of platform boundaries may be an essential lever of action to federate and sustain a vibrant innovation ecosystem. As we know that a platform's ability to attract innovator-complementors constitutes a fundamental source of competitive advantage over rival platforms (Gawer & Cusumano, 2008), such a study, together with the propositions developed in this article, would then lead to a deeper understanding of the role of platform boundary setting on platform ecosystem's survival, resilience and growth.

This study also points to the direction of two more avenues for future research. It suggests that more research is needed on the topic of ecosystem governance. Platform leaders such as Intel, Apple or Google seem to have understood the importance of being perceived as legitimate, not only by their complementors but by the regulator. The greater the ecosystem members' perception of the fairness of the platform leader, the less "pushback" the platform leader will receive from complementors and the regulator. It may be that in order to compensate for the real possibility, and the hard-to-forget instances, of abuse of "hard power" that comes with the territory of being a platform leader, that these organizations are learning that they may be better off using "soft power" (Nye, 2004) -- the ability to get desired outcomes because others want what you want --in other words establishing ecosystem governance that creates conditions of mutually enhancing business models, lest they suffer

significant backlash from coalitions of disgruntled complementors and/or the regulator. What constitutes good ecosystem governance, which has been described by Wareham et al (2014) as finding the right balance between "generativity and control" promises therefore to be a fruitful area for further research.

Last, by identifying technological interfaces as a kind of organizational boundary, the paper contributes to further theory development or organization boundaries theory, in a way that is consistent with the various authors who argue that organizational theory needs to develop a richer and more sophisticated understanding of technology. While novel, the conceptual leap to consider technological interfaces as organizational boundaries is consistent with the recent literature on materiality of technology (Orlikowski and Scott, 2008; Leonardi & Barley, 2008). Various authors have indeed repeatedly pointed out that technology and materiality do not receive adequate treatment in organization studies. Orlikowski (2007, p. 1436) puts it succinctly when she argues that, despite the 'considerable amount of materiality entailed in every aspect of organizing …, materiality has been largely ignored by organizational theory, which appears to assume (often implicitly) that it does not matter or does not matter very much in everyday organizing'. For Orlikowski and Scott (2008), artifacts are 'missing in action' in the study of organizations. In technological platforms, I have shown that technological interface act not only as a physical connector between material artifacts, but that they also embody a demarcation and articulate modes of interaction between different categories of social actors. By being "open" or "closed", by being shifted "outward" or not, not only technological interfaces can facilitate information exchange and either include or exclude agents from the platform organization, they can also attract or repel collaboration or competition from others. This does not imply, as Leonardi and Barley (2008) explain, a return to technological determinism, nor an automatic mirroring effect between the architecture of technologies and organizational architectures, but rather this takes seriously

Orlikowski (2007)'s insight that "the social and the material are constitutively entangled, and inextricably related" (Orlikowski, 2007, p. 1437). Developing a more precise and nuanced understanding of technology as an integral part of organizations promises to be a fruitful area of further study, and the phenomenon of technological platforms constitute a rich empirical setting in which to further develop concepts that better articulate the between link technology and organizations.

References

Adner, R., R. Kapoor, 2010. Value creation in innovation ecosystems: How the structure of technological interdependence affects firm performance in new technology generations. Strategic Management J. **31**(3) 306-333.

Anderson E.G., Parker G.G., Tan B. 2014. Platform Performance Investment in the Presence of Network Externalities. Information System Research, **25**: 152–172.

Armstrong, M., 2006. Competition in Two-Sided Markets. RAND J. of Economics **37** 668-691.

Baldwin, C. Y. 2008. Where do transactions come from? Modularity, transactions, and the boundaries of firms. Indust. Corporate Change **17**(1) 155-195.

Baldwin, C. Y., K. B. Clark. 1997. Managing in an age of modularity. Harvard Bus. Rev.**75**(5) 84-93.

Baldwin, C. Y., K. B. Clark. 2000. Design Rules: The Power of Modularity. Vol. 1. MIT Press, Cambridge, Mass.

Baldwin, C. Y., E. von Hippel. 2011. Modeling a paradigm shift: From producer innovation to user and open collaborative innovation. Org. Sci. **22**(6) 1399-1417.

Baldwin, C. Y., J. Woodard. 2009. The architecture of platforms: A unified view. A. Gawer, ed. Platforms, Markets and Innovation. Edward Elgar, Cheltenham, UK and Northampton, Mass, 19-44.

Barney, J. 1991. Firm resources and sustained competitive advantage. J. Management. **17**(1) 99-120.

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

Boudreau, K. J. 2012. Let a thousand flowers bloom? An early look at large numbers of software app developers and patterns of innovation. Org. Sci. **23**(5) 1409-1427.

Boudreau, K. J., A. Hagiu. 2009. Platform rules: multi-sided platforms as regulators. A. Gawer, ed. Platforms, Markets and Innovation. Edward Elgar, Cheltenham, UK and Northampton, Mass., 163-191.Brandenburger, A., B. J. Nalebuff. 1997. Co-Opetition. Currency Doubleday, New York.

Bresnahan, T., S. Greenstein. 2014. Mobile computing : The next platform rivalry. American Economic Review: Papers & Proceedings **104**(5) 475-480.

Brusoni, S., A. Prencipe, K. Pavitt. 2001. Knowledge specialization, organizational coupling, and the boundaries of the firm: Why do firms know more than they make? Admin. Sci. Quart. **46**(4) 597-621.

Brusoni S., A. Prencipe. 2006. Making design rules : Amultidomain perspective. Org Sci. **17**(2) 19-189.
Cabigiosu, A., A. Camuffo. 2012. Beyond the « mirroring » hypothesis : Product modularity and interorganizational relations in the air conditioning industry. Org. Sci. **23**(3) 686-703.
Carlton, D., M. Waldman. 2002. The strategic use of tying to preserve and create market power in evolving industries. RAND J. of Economics **33**(2) 194-220.
Carlton D., M. Waldman. 2005. Tying, upgrades, and switching costs in durable-goods markets. No. 11407. National Bureau of Economic Research.
Ceccagnoli M, Forman C, Huang P, Wu DJ. 2012. Co-creation of value in a platform ecosystem: the case of enterprise software. MIS Quarterly **36**(1): 263-290.
Chandler, A. D. 1977. The Visible Hand: The Managerial Revolution in American Business. Harvard University Press: Cambridge, Mass.
Chesbrough, H. W. 2003. Open Innovation: The New Imperative for Creating and Profiting from Technology. Harvard Business School Press, Boston, Mass.
Chesbrough, H. W., K. Kusunoki. 2001. The modularity trap: Innovation, technology phase shifts and the resulting limits of virtual organizations. I. Nonaka, D. J. Teece, eds. Managing Industrial Knowledge: Creation, Transfer and Utilization, 202-230.
Clark, K. B. 1985. The interaction of design hierarchies and market concepts in technological evolution. Research Policy **14**(5) 235-251.
Coase, R. H. 1937. The nature of the firm. Economica **4**(16) 386-405.
Colfer, L., C. Y. Baldwin. 2010. The mirroring hypothesis: Theory, evidence and exceptions. Working Paper 10-058, Harvard Business School, Boston.
Dhanaraj C, Parkhe A. 2006. Orchestrating innovation networks. Academy of Management Review **31**(3) 659-669.
Dougherty, D., D. Dunne. 2011. Organizing ecologies of complex innovation. Org. Sci. **22**(5) 1214-1223.
Eisenmann, T., G. Parker, M. Van Alstyne. 2006. Strategies for two-sided markets. Harvard Business Rev., October.
Eisenmann, T., G. Parker, M. Van Alstyne. 2009. Opening platforms: How, when, and why? A. Gawer, ed. Platforms, Markets and Innovation. Edward Elgar, Cheltenham, UK and Northampton, Mass, 131-162.
Eisenmann, T., G. Parker, M. Van Alstyne. 2011. Platform envelopment. Strategic Management J. 32(12) 1270-1285.
Evans, D. S. 2003. Some empirical aspects of multi-sided platform industries. Rev. Network Economics **2**(3).
Evans, D. S., A. Hagiu, R. Schmalensee. 2006. Invisible Engines: How Software Platforms Drive Innovation and Transform Industries. MIT Press, Cambridge, Mass.
Evans, D. S., R. Schmalensee. 2008. Markets with two-sided platforms. Issues in Competition and Law and Policy (ABA Section of Antitrust Law) **1**(28) 667-693.
Farrell J., M. L. Katz. 2000. Innovation, rent extraction, and integration in systems markets. J. Industrial Economics **97**(4) 413-432.
Farrell, J., Weiser, P. J. 2003. Modularity, vertical integration, and open access policies: Towards a convergence of antitrust and regulation in the Internet age, Harvard J. Law and Technology **17**(85) 105-19.
Garud, R., A. Kumaraswamy. 1995. Technological and organizational designs to achieve economies of substitution. Strategic Management J. **16** 93-110.
Garud, R., A. Kumaraswamy. 2002. Institutional entrepreneurship in the sponsorship of common technological standards: The case of Sun Microsystems and Java. Acad. Management J. **45**(1) 196-214.

Gawer, A. 2009. Platforms, markets and innovation: An introduction. A. Gawer, ed. Platforms, Markets and Innovation. Edward Elgar, Cheltenham, UK and Northampton, Mass., 1-16.

Gawer A. 2014. Bridging differing perspectives on technological platforms: Toward an integrative framework. Research Policy **43**(7): 1239-1249.

Gawer, A., M. A.., Cusumano. 2002. Platform Leadership: How Intel, Microsoft, and Cisco Drive Industry Innovation. Harvard Business School Press, Bostson, Mass.

Gawer, A ., M. A. Cusumano. 2008. How companies become platform leaders. MIT Sloan Management Review 49.

Gawer, A ., M. A. Cusumano. 2013. Industry platforms and ecosystem innovation. Journal of Product Innovation Management 31: 417-433.

Gawer, A., Henderson, R. 2007. Platform owner entry and innovation in complementary markets: Evidence from Intel**.** J. Econom. Management Strategy **16**(1) 1-34.

Gawer, A., N. Phillips. 2013. Institutional work as logics shift: The case of Intel's transformation to platform leader. Org. Studies. In press.

Ghazawneh, A., O. Henfridsson. 2012. Balancing platform control and external contribution in third-parrty development: The boundary resources model. Information Systems Journal **23**(2) 173-192.

Iansiti, M., R. Levien. 2004. The Keystone Advantage: What the New Dynamics of Business Ecosystems Mean for Strategy, Innovation, and Sustainability. Harvard Business School Press.

Jacobides, M. G., S. Billinger. 2006. Designing the boundaries of the firm: From "make, buy, or ally" to the dynamic benefits of vertical architecture. Org. Sci. **19**(2), 249-261.

Jacobides, M.G., Knudsen, T., Augier, M. 2006. Benefiting from innovation: Value creation, value appropriation and the role of industry architectures. Research Policy 35 (6), 1200–1221.

Jacobides, M.G., S. G. Winter. 2005. The co-evolution of capabilities and transaction costs: Explaining the institutional structure of production. Strategic Management J. **26**(5) 395-413.

Jobs, Steve "Thoughts on Flash", 29 April 2010. http://www.apple.com/hotnews/thoughts-on-flash/

Jiao, J. R., T. W. Simpson, Z. Siddique. 2007. Product family design and platform-based product development: A state-of-the-art review. J. Intelligent Manufacturing **18**(1) 5-29.

Katz, M. L., C. Shapiro. 1985. Network externalities, competition, and compatibility. American Economic Rev. **75**(3) 424-440.

Katz, M. L., C. Shapiro. 1986. Technology adoption in the presence of network externalities. J. Political Economy **94**(4) 822-841.

Krishnan, V., G. Gupta. 2001. Appropriateness and impact of platform-based product development. Management Sci. **47**, 52–68.

Langlois, R. N. 2002. Modularity in technology and organization. J. Econom. Behavior and Organization **49** 19–37.

Langlois, R. N., P. Robertson. 1992. Networks and innovation in a modular system: Lessons from the microcomputer and stereo component industries. Research Policy **21**(4) 297-313.

Lawrence, T.B., R. Suddaby. 2006. Institutional work: Actors and agency in institutional studies of organizations. Cambridge University Press.

Leonardi, P. M., S. R. Barley. 2008. Materiality and change: Challenges to build better theory about technology and organizing. Information and Organization **18**(3) 159-176.

MacDuffie, J.-P. 2013. Modularity-as-process and modularity-as-frame: Lessons from product architecture initiatives in the global automotive industry. Global Strategy J. **3**(1) 8-40.
Meyer, M. H., Lehnerd, A. P. 1997. The Power of Product Platforms: Building Value and Cost Leadership. Free Press, New York.
Nalebuff, B. 2004. Bundling as an entry-deterrent. Quarterly J. Economics **119**(1) 159-187.
Nambisan, S., M.Sawhney. 2011. Orchestration processes in network-centric innovation: Evidence from the field. Acad. Management Perspectives **25**(3) 40-57.
Nguyen, Thi (1999) "Intergraph loses lawsuit against Intel", Windows IT Pro, 29 November.
Nye, J. S. 2004. Soft Power: The Means to success in World Politics. Public Affairs Store, Perseus.
Ordover, J., A. Sykes, R. Willig. 1985. Nonprice anticompetitive behavior by dominant firms towards the producers of complementary products. F. Fisher, ed. Antitrust and Regulation Essays in Memory of John J. McGowan MIT Press, Cambridge, Mass.
Orlikowski, W. J. 2007. Sociomaterial practices: Exploring technology at work. Org. Studies **28**(9) 1435–1448.
Orlikowski, W. J., S. V. Scott. 2008. Sociomateriality: Challenging the separation of technology, work and organization. Acad. of Management Annals **2**(1) 433–474.
Ozcan, P., K. M. Eisenhardt. 2009. Origin of alliance portfolios: Entrepreneurs, network strategies and firm performance. Acad. Management J. **52**(2) 246-279.
Panzar, J. C. 1989. Technological determinants of firms and industry structure. R. Schmalensee, R. D.Willig, eds. Handbook of Industrial Organization **13**.
Parker, G., M. Van Alstyne. 2005. Two-sided network effects: A theory of information product design. Management Sci. **51** 1494-1504.
Parnas, D. L. 1972. On the criteria to be used in decomposing systems into modules. Communications of the ACM **15**(12) 1053-1058.
Pavitt, K. 2003. Specialization and systems integration: Where manufacture and services still meet. A. Prencipe, A. Davies, M. Hobday, eds. The Business of System Integration. Oxford University Press, Oxford, UK, 78-91.
Penrose, E. 1959. The Theory of the Growth of the Firm. Basil Blackwell, Oxford, UK.
Pfeffer, J., G. Salancik. 1978. The External Control of Organizations: A Resource Dependence Perspective. Harper & Row, New York.
Pinch, T. 2008. Technology and institutions: Living in a material world. Theory and Society **37** 461–483.
Porter, M. E. 1980. Competitive Advantage: Creating and Sustaining Superior Performance. Free Press, New York.
Prencipe, A. 1997. Technological competencies and product's evolutionary dynamics: A case study from the aero-engine industry. Research Policy **25**(8) 1261-1276.
Rochet, J.-C., J. Tirole. 2003. Platform competition in two-sided markets. J. European Econ. Association **1**(4), 990-1029.
Rochet, J.-C., J. Tirole. 2006. Two-sided markets: A progress report. RAND J. of Economics **35** 645-667.
Rysman, M. 2009. The economics of two-sided markets. J. Econ. Perspectives **23**(3) 125-143.
Sanchez, R., J. T. Mahoney. 1996. Modularity, flexibility, and knowledge management in product and organization design. Strategic Management J. **17** 63-76.
Sanderson, S .W., M. Uzumeri. 1995. Managing product families: The case of the Sony Walkman. Research Policy **24**(5) 761–782.
Santos, F. M. and K. M. Eisenhardt. 2005. Organizational boundaries and theories of organization. Org. Sci. **16**(5) 491-508.

Schilling, M. A., 2000. Towards a general modular system theory and its application to interfirm product modularity. Academy Management Rev. **25**(2) 312-334.
Simon, H. A. 1962. The architecture of complexity. Proceedings of the American Philosophical Society **106**(6) 467-482.
Staudenmayer, N., M. Tripsas, C. L. Tucci. 2005. Interfirm modularity and its implications for product development. J. Product Innovation Management **2** 303-321.
Takeishi, A. 2002. Knowledge partitioning in the interfirm division of labor: The case of automotive product development. Org. Sci. **13**(3) 321-338.
Ulrich, K. 1995. The role of product architecture in the manufacturing firm. Research Policy **24**(3) 419-440.
Wareham J, Fox PB, Cano Giner JL. 2014. Technology ecosystem governance. Organization Science, **25**(4) 1195–1215.
Weick, .E. 1995. Sensemaking in Organizations. Sage Publications, Thousand Oaks, California.
Wernerfelt, 1984. A resource-based view of the firm. Strategic Management J. **5**(2) 171-180.
West, J. 2007. The economic realities of open standards: Black, white, and many shades of grey. S. Greenstein, V. Stango, eds. Standards and Public Policy. Cambridge University Press, Cambridge, UK, 87-122.
Wheelwright, S. C., K. B. Clark. 1992. Creating project plans to focus product development. Harvard Business Rev. **70** (2) 67–83.
Whinston, M. D. 1990. Tying, foreclosure, and exclusion. American Economic Rev.September, 837–859.
Wry, T., M. Lounsbury, M. A. Glynn. 2011. Legitimating nascent collective identities: Coordinating cultural entrepreneurship. Org. Sci. **22**(2) 449–463.
Yoo, Y., R. J. Boland, K. Lyytinen, A. Majchrzak. 2012. Organizing for innovation in the digitized world. Org Sci. **23**(5) 1398-1408.
Zirpoli, F., M. C. Becker. 2011. The limits of design and engineering outsourcing: Performance integration and the unfulfilled promises of modularity. R&D Management **41**(1) 21-43.

Table 1: Drivers of platform boundary shifts: Summary of propositions

	Scope		Interface Openness	
	Expansion	**Restraint**	**Towards Closing**	**Towards Opening**
Efficiency	P1: scope expansion in the context of economies of scope leads to efficiency gains			
Power	P2: scope expansion weakens rivals		P3: interface closing weakens complementors-turned-rivals	
Competence	P5: scope expansion in the context of strong firm-level integration capabilities stimulates internal, systemic innovation			P4: interface opening in the context of distributed external capabilities stimulates complementors' modular platform-enhancing innovation
Identity		P6: Scope restraint reinforces legitimacy as benevolent platform leader and strengthen complementors' innovation incentives		