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Competition and Cooperation in Ecosystems: How Industry Evolution and Governance Inseparability Shape Value Capture over Time

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Abstract

This paper draws on industry evolution and governance inseparability to analyze the dynamics between competitive and cooperative strategies in business ecosystems. We argue that these are shaped by changing incentives for value creation and capture over the ecosystem lifecycle and the industry it serves, and the path-dependent evolution of contractual arrangements governing ecosystem participation. The initial bargaining power of nascent ecosystems leaders translates into initial arrangements that, in the presence of governance inseparability, shape the division of value created by the ecosystem over its life cycle. Consequently, controlling a bottleneck (a difficult to replace segment where value accrues) in a mature ecosystem may be neither sufficient nor necessary for capturing a large share of the value created. ARM, a firm that controls a bottleneck in the semiconductor ecosystem, illustrates our framework.

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ABSTRACT

This paper draws on industry evolution and governance inseparability to analyze the dynamics between competitive and cooperative strategies in business ecosystems. We argue that these are shaped by changing incentives for value creation and capture over the ecosystem lifecycle and the industry it serves, and the path-dependent evolution of contractual arrangements governing ecosystem participation. The initial bargaining power of nascent ecosystems leaders translates into initial arrangements that, in the presence of governance inseparability, shape the division of value created by the ecosystem over its life cycle. Consequently, controlling a bottleneck (a difficult to replace segment where value accrues) in a mature ecosystem may be neither sufficient nor necessary for capturing a large share of the value created. ARM, a firm that controls a bottleneck in the semiconductor ecosystem, illustrates our framework.

Keywords: Ecosystem, Bottleneck, Industry life cycle, Governance inseparability, Value capture

INTRODUCTION

This paper builds on the growing literature which focuses on the way value is created and distributed among groups of co-dependent firms, centered around concepts such as 'ecosystems' (Iansiti and Levien, 2004; Adner and Kapoor, 2010; Adner 2012), 'platforms' (Gawer and Cusumano, 2002; Gawer, 2010), and 'industry architectures' (Jacobides, Knudsen, and Augier, 2006; Pisano and Teece, 2007), that are characterized by both cooperation and competition between participants. These studies have identified a rich mix of cooperative and collaborative interactions among heterogeneous firms within the ecosystem as key drivers of value creation and value capture (Adner and Kapoor, 2010; 2015). While recent studies enhanced our understanding of the structural and strategic conditions affecting a firm's ability to capture a large share of the total value created by the ecosystem (Adner and Kapoor, 2010; Jacobides et al., 2006),[1] the current literature has so far overlooked how firms simultaneously manage value creation and appropriation in cooperative relations during the ecosystem's life cycle. To improve our understanding of these dynamics, this paper investigates the relationship between the initial conditions under which the ecosystem leader initiated its efforts to create the ecosystem and the value captured by the ecosystem leader over the life-cycle of the ecosystem and the industry it serves.[2]

In particular, the initial conditions we focus on are 1) the degree to which the focal firm has an established network of suppliers, customers, and complementors,[3] which it can leverage in its efforts to create a vibrant ecosystem, and 2) the life cycle stage of the industry which the ecosystem serves. For the first point, entering an ecosystem without an established network of partners denote a less standardized and more malleable ecosystem architecture and low initial bargaining power for the ecosystem leader, while the opposite is true if the

[1] Value capture is defined as the amount each agent gets from the aggregate quantity of economic value generated through the activities of ecosystem members (MacDonald and Ryall, 2004).
[2] We define the ecosystem leader as the focal firm in the ecosystem that decides on the governance arrangements and offers these conditions accordingly through a contract or a license to its ecosystem partners.
[3] From this point on we will refer to them as 'partners'.

ecosystem is led by an ecosystem leader with an existing network of partners operating under established governance arrangements, reflecting a more established ecosystem architecture (Jacobides et al., 2006). For the second point, driven by technological imperatives or by demand side shifts, the emerging stage of the industry life cycle is denoted by high growth opportunities, while growth opportunities in the mature stage are low (Klepper, 1996; Adner and Levinthal, 2001). Because of path dependencies created by these initial conditions, constraints on changes in governance mechanisms and bargaining power along the ecosystem life cycle and the evolution of supply and demand side growth opportunities over the industry life cycle are important drivers of a firm's ability to capture value in ecosystems.

To explain how these initial conditions affect the value captured by the ecosystem leader, we introduce a framework that combines work on industry evolution (Langlois and Robertson, 1995; Klepper, 1996; Jacobides and Winter, 2005; Jacobides et al., 2006), and governance inseparability (Argyres and Liebeskind, 1999; 2002). Our framework suggests that as the industry served by an ecosystem evolves from emergence to maturity, the focal concern of ecosystem participants will shift from value creation to value capture (Di Stefano, Gambardella, and Verona, 2012; Moore, 1993). The early stage of an ecosystem life cycle is characterized by a fluid architecture and loose relationships between ecosystem participants, while the established stage denotes a period with relationships already set (Moore, 1993, Jacobides et al., 2006). Therefore, the value captured by the ecosystem leader over the ecosystem's life cycle requires a value creation focus which results in high levels of cooperation in the early stages and a value capturing focus which results in high levels of competition in the latter stages. The ability of the ecosystem leader to alter governance arrangements to capture more value from a maturing ecosystem and industry is likely to be limited by governance inseparability (Argyres and Liebeskind, 1999; 2002), arising from commitments made by the ecosystem leader to its partners in the early stages of ecosystem development. Therefore, the initial bargaining power of an ecosystem leader, which determines how the governance arrangements within the architecture of an ecosystem are set up, has consequences for its ability to capture value in the later stages of an ecosystem's life cycle as the resulting relationships and interdependencies become more established and difficult to alter. This effect is further pronounced as the industry which the ecosystem serves also reaches maturity, as opportunities for value creation decrease due to slowing pace in technological development and demand growth.

Our paper contributes to existing work that has focused on how competition and cooperation relate in terms of value creation and appropriation in ecosystems. In particular, existing work in this area has suggested how firms that control a "bottleneck" segment, i.e., the least replaceable part of an ecosystem where value accrues, can gain architectural advantage and higher bargaining power, and capture above average rents (Jacobides et al., 2006; Pisano and Teece, 2007; Baldwin, 2010; Jacobides and Tae, 2014). However, the degree to which a firm occupying a bottleneck segment can capture value may be affected by the contractual arrangements set early on within an ecosystem. If the ecosystem leader initiates its efforts to create the ecosystem without having an existing network of suppliers, customers, and complementors to draw on, its initial bargaining power will be low, limiting its ability to establish favorable governance arrangements. In this case, control over a bottleneck segment may not be sufficient to increase its share of value captured as the industry served by the ecosystem matures. By contrast, if the ecosystem leader is able to build on its existing partnerships with suppliers, customers, and complementors as it initiates its ecosystem-creation efforts, its higher initial bargaining power may safe-guard its ability to capture a greater share of value as the industry served by the ecosystem matures. Thus, it may not be necessary for a firm to control a bottleneck segment in order capture a disproportionate share of the value created by the ecosystem.

As an illustration, consider the case of Advanced RISC Machines Ltd. (ARM), the leading supplier of semiconductor intellectual property (IP) specializing in the design of energy-efficient processors, which it licenses to a wide range of partners. In 2014, ARM's processor architecture was used in over 95% of the world's mobile devices, with ARM's partners shipping 12 billion chips into this industry, driven by the worldwide growth in the number of smartphones and other mobile computers (ARM Annual report, 2014). ARM's processor architecture is complementary with their partner's assets, such as mobile device designs and semiconductor fabrication plants, in the sense that these assets are mutually adapted and that their combined use produces superior value (Jacobides, et al., 2006). Also, as ARM licenses its designs to a large number of partners while facing little effective competition from other semiconductor IP providers targeting the mobile device industry,[4] its factor mobility relative to its partners appears to be low. Furthermore, as ARM's IP has become the standard for the mobile device industries,[5] and as few firms have the wherewithal to internally develop a chip architecture that is better than ARM's library of IP for processor designs, switching costs and network externalities are very high. ARM thus appears well-positioned to control the "bottleneck" in today's semiconductor ecosystem that serves the mobile device industry, and can therefore be expected to appropriate a large share of the value created by the ecosystem, despite its lack of downstream vertical integration. However, ARM's revenues of $913.1 million, the majority of which come from license and royalty fees for chips sold in mobile devices (ARM Annual report, 2013), are only a small fraction of the

[4] Numerous entrepreneurial startups have attempted to enter into IP business so far, however only Tensilica (offering a completely new concept with "Dataplane"), CEVA (offering DSP IP core) or Imagination Technologies (offering GPU IP core instead of CPU) have been successful.
[5] The entire ecosystem of chip manufacturers (e.g. TSMC), software providers (e.g. Apple's iOS and Google's Android), and application developers have invested a huge amount of resources, time, and money to develop the software pieces around ARM-based chipsets.

$30.9 billion revenue generated by the mobile phone application-specific semiconductor ecosystem (Gartner, 2012).[6]

In the case of ARM, we argue that its choice of licensing terms during the emergence of the mobile device ecosystem in the 1990s inhibits ARM's current ability to switch its governance mode for new licensees as the mobile device industry evolves towards maturity, resulting in ARM capturing a relatively small share of the value created in the ecosystem. In particular, ARM's use of perpetual licenses, which give some partners the right to perpetually design and manufacture chips based on a particular generation of the ARM architecture, has persisted as the ecosystem has grown. Such licenses were likely necessary in the early stages of the ecosystem's development as a safeguard for ARM's initial partners against opportunistic hold-up behavior by ARM, but their continued use restricts ARM's enforcement of their increasing bargaining power, and thus, their ability to appropriate a greater share of value by altering the terms of new licensing deals. This is because perpetual licenses give ARM's partners the viable option of not licensing a new architecture generation and continuing to develop processors based on the architecture they currently license instead. This effect is further pronounced as a result of the apparent maturity of the developed country smartphone industry.

BACKGROUND LITERATURE

The interplay between competition and cooperation in ecosystems. The literatures on network relations of firms and on strategic alliances have shown that a firm can be involved in different types of horizontal relationships of competition and cooperation at the same time (Ahuja, 2000; Silverman and Baum, 2002). While the literature on cooperation has evolved separately from that of competition, it can be said that changes in market structure and

[6] Other measures of value capture, such as Return on Invested Capital (ROIC), also confirm the lower value captured by ARM from the ecosystem. This is discussed in detail later in the paper.

bargaining power among horizontal or vertical relationships in business networks entail a dynamic governance arrangement to reflect the simultaneous competition and collaboration among partners (Jacobides et al, 2006; Basole, Park, and Barnett, 2014). In this sense, ecosystems provide a unique setting to connect the separate streams of research on competitive strategy and cooperative strategy and highlight value creation and appropriation in coopetitive interactions (Adner and Kapoor, 2010). Very few studies have exploited this opportunity so far, and the evolution of the ecosystem from emergence to maturity (in terms of its architecture) shows how the complex interplay between competitive and cooperative strategies are reflected in the incentives to collaboration and contractual arrangements to govern these relations (Minà, Dagnino, and Letaifa, 2015).

Ecosystems, bottlenecks, and value capture. In a business or innovation ecosystem, a group of firms is linked by transactions and complementarities, and engaged collectively in the provision of a product or service to end users (Moore, 1996; Iansiti and Levien, 2004; Adner and Kapoor, 2010; Williamson and De Meyer 2012; Adner, Oxley, & Silverman, 2013).[7] Several studies have pointed the importance of different strategic moves by ecosystem leaders, such as inducing coordination and stimulating value creation among ecosystem partners (Gawer and Cusumano, 2002), incentivizing partners to join and invest in the ecosystem (Gawer and Henderson, 2007), and more broadly, designing the ‘rules of the game’ in the ecosystem (Iansiti and Levien, 2004).

As ecosystems evolve, templates for division of labor (“who does what?”) and value appropriation (“who receives what?”), i.e., their industry architectures (Jacobides et al., 2006;

[7] These may include several groups of stakeholder firms such as, component suppliers, partners, developers, users, buyers, complementors, rivals, universities, research institutions, and communities. The management literature on ecosystems has also referred to “business ecosystems” (Adner et al., 2013) or “innovation ecosystems” (Adner and Kapoor 2010) – in this paper we simply use the term “ecosystem”. This is also consistent with industry practitioners (e.g. in IT hardware and software), whose use of the term ecosystem is largely consistent with the management literature.

Pisano and Teece, 2007), may shift.[8] Jacobides et al. (2006) identified complementarity and factor mobility as two distinct components of co-specialization. Complementarity refers to the extent to which two mutually adapted factors can yield superior value creation in combination, whereas factor mobility refers to how plentiful are the alternatives to these factors. These two concepts together give rise to architectural advantage, defined as the ability to capture more value without the need to engage into vertical integration. Jacobides et al. (2006, p. 1200) state that such "architectural advantage comes about when firms can enhance both complementarity and mobility in parts of the value chain where they are not active". The concept of industry architectures suggests that focal firms that have the power to design the division of labor and surplus, gain dominance through inducing coordination and stimulate value creation among several other groups of partners. This helps them enjoy higher bargaining power and turn their own niche into a bottleneck, i.e., a part of the industry which has lower asset mobility and decreased competition than other niches. Such bottlenecks determine how power and profits shift along the value chain (Jacobides et al., 2006; Jacobides and Tae, 2014). In line with the literature, we define bottlenecks as the least replaceable parts of an ecosystem's value chain or its (industry) architecture with high complementarity and low factor mobility.

Bottlenecks generally refer to areas where the overall system performance is constrained by one or more of its components (Ethiraj, 2007). They affect the rate and direction of problem solving and thereby have long term implications for technological innovation (Rosenberg, 1969). Relatedly, Jacobides and Tae (2014), based on data from the computer industry, highlight the role of "kingpins", "uniquely superior or powerful firms within a segment", firms that by establishing their segment as a bottleneck, increase the

[8] The concept of industry architecture is related to the idea of an ecosystem, but we regard them as conceptually distinct. In particular, while the ecosystem literature has focused on a variety of issues such as innovation (Adner and Kapoor 2010), strategic behavior (Iansiti and Levien, 2004), and collaboration (Kapoor, 2013), work on industry architecture has focused more explicitly on how sector wide division of labor affects value capture (cf. Pisano and Teece, 2007; Brusoni, Jacobides, and Prencipe, 2009; Tee and Gawer, 2009).

segment's overall share of industry-wide value. Further, existing work has shown that the location of bottlenecks (upstream or downstream vis-à-vis the focal firm) can have important outcomes in terms of market share (Adner and Kapoor, 2010). In particular, Adner and Kapoor (2010) show how, in the semiconductor lithography equipment industry, changes in market leadership depend on whether the bottlenecks are located in components or complements. The position of bottlenecks typically changes as technologies develop and knowledge accumulates across industry participants. This gives way to strategic opportunities to arise for entry. For instance, Baldwin (2010) suggests how superior architectural knowledge about a system's bottlenecks allows entrepreneurial startups to successfully compete with incumbent firms. In particular, firms can focus on developing superior bottleneck modules, and simultaneously outsourcing and inducing complementors to supply non-bottleneck components.

Yet, though we know that the location of bottlenecks can have important strategic outcomes for individual firms and the ecosystem as a whole, we have little insight into the conditions determining the degree to which a firm can capture value when it controls a bottleneck.

Industry evolution and firm specialization. The industry evolution literature has long ago defined different stages of a single industry's life cycle (Gort and Klepper, 1982). An industry initially has an emergent phase where demand grows rapidly, and on the supply side numerous alternative product designs exist. Over time, the industry reaches a maturity stage as alternative technological growth opportunities are depleted, and demand growth slows down. Following the emergence of a dominant design, the industry consolidates and evolves towards a homogenous large scale commodity product structure (Utterback and Suarez, 1993). This view of industry evolution, however, certainly depends to some extent on the assumption that the industry's product is substantially homogeneous (Knudsen, Levinthal, and Winter, 2014, and there is no scope for vertical disintegration or cooperation among firms, that all firms are able to produce and sell that product.

Ecosystems typically comprise of collaborating firms from multiple industries and vertical layers (Adner and Kapoor, 2010), and they are best understood as a cluster or network of evolving and interrelated product markets or submarkets (Klepper and Thompson, 2006; Christensen, 2010). This heterogeneous structure within ecosystems makes it difficult to apply the homogenous product and firm structure view in industry evolution to these contexts. Particularly, the relationship between the emergence of entrepreneurial opportunities for value creation and industry evolution with regard to ‘when’ these opportunities should rise or decline has been one source of disagreement among different literatures (Funk, 2014; Hang, Garnsey, Ruan, 2014). On the one hand, the industry life cycle (Gort and Klepper, 1982; Klepper, 1997) and technology management (Anderson and Tushman, 1990; Utterback and Suarez, 1993) literatures state that the early phase of an industry denotes ubiquitous opportunities for entry which decrease over time and ends with the coalescence of an industry around a particular technology among many competing alternative technologies, dubbed a dominant design (Christensen, Suarez, Utterback, 1998). On the other hand, recent literatures analyzing interactions between multiple layers within supply chains state that as industries evolve from emergence and growth to maturity, vertical integration transforms into specialization (Jacobides, 2005; Jacobides and Winter, 2005; Jacobides et al., 2006), and interdependencies become more important as entrepreneurial opportunities in vertically specialized niches become viable (Gulati, Puranam, Tushman, 2012). Literature on modular design supports this latter view, stating that after the emergence of a dominant design, standard interfaces emerge (Shapiro and Varian, 1999) which define how functional components or ‘modules’ will interact, increasing compatibility and substitutability among component variations (Brusoni and Prencipe, 2001), thus opportunities for specialized entrants (Funk, 2014).

Yet, literatures on the evolution of ecosystems and the industries they serve has not documented the interaction between changes in the vertical disintegration and thus the bargaining power of collaborating firms and changes in the industry structure in terms of the supply and demand side value creation opportunities, which is an important determinant of value capturing by ecosystem members over time.

Governance inseparability. As ecosystems comprise heterogeneous groups of firms that are engaged collectively in the provision of products and/or services to end users, the coordination of these groups' efforts requires an ecosystem governance structure. Rules and standards that shape the interactions between ecosystem participants evolve in all ecosystems (Gawer and Cusumano, 2002; Iansiti and Levien, 2004; Adner, 2012). Such shared rules and standards are particularly important in collaborative networks, where ecosystem participants often compete and collaborate simultaneously to create value (Nalebuff and Brandenburger, 1996; Evans and Wolf, 2005). The early stage of an ecosystem life cycle is characterized by a fluid architecture and loose relationships between ecosystem participants, while the established stage denotes a period in which the relationships are concrete and well-established (Moore, 1993, Jacobides et al., 2006).

Argyres and Liebeskind (1999; 2002) introduced to transaction cost economics literature the concept of "governance inseparability", which refers to the idea that prior contractual commitments made by a focal firm constrain its ability to differentiate or alter future governance arrangements. Governance inseparability can also arise as a result of changes in the bargaining power between exchange partners.

The ecosystem's initial governance arrangements may thus be difficult to alter as ecosystems evolve, due to both the commitments made by the initial members of the ecosystem and to changes in the bargaining power of different ecosystem participants in the course of the ecosystem's evolution. Governance inseparability concerns are therefore particularly salient for firms aiming to maneuver themselves to control of a bottleneck position (or protect their existing position in control of a bottleneck) as the ecosystem develops.

Two kinds of constraints on firm governance options may arise as a result of governance inseparability: constraints on governance switching, and constraints on governance differentiation (Argyres and Liebeskind, 1999). Constraints on governance switching exist if a firm cannot enter into an efficient governance arrangement of a certain type for a kind of transaction in future periods, due to it already having in place a different governance arrangement for this kind of transaction.[9] For example, Coca Cola's exclusive franchising agreements with independent bottling companies have constrained its ability to integrate forward into bottling, as these agreements prevent any company other than the franchisee to bottle Coca Cola products in a given territory. As a result of this, Coca Cola could only integrate forward by buying out its own franchisees (Argyres and Liebeskind, 1999: p.52). Constraints on governance differentiation, on the other hand, arise when a focal firm is obliged to enter into a governance arrangement of a particular type with an exchange partner due to it already having a governance arrangement of that type with a different partner. For example, increasing bargaining power of unionized labor in the long-haul trucking and airline industries in the United States has led to some firms being unable to effectively set up subsidiaries serving a different market niche, such as short-haul trucking or shorter flights. In both of these cases, attempts to differentiate employment conditions within the subsidiary from the main firm failed in the face of unionized labor resistance (Argyres and Liebeskind, 1999: p.56).

[9] While the definition given in Argyres and Liebeskind (1999, p.52) specifies different present and future counter-parties, the examples given on pp.55-56 of the same paper show that constraints on governance switching can also affect the governance of transactions between the same two exchange partners over time.

Governance inseparability is a further reason why firms occupying bottleneck positions within an ecosystem may fail to capture large share of the value that the ecosystem creates. Specifically, the governance arrangements agreed between the ecosystem leader and its initial partners in the early stages of ecosystem development shape the division of labor and the share of value captured by different ecosystem participants. As the ecosystem matures, the terms under which new members can join the ecosystem become stabilized, and the number of ecosystem participants operating under these terms grows. This increasing rigidity of the ecosystem's governance arrangements, and the increasing number of participants agreeing to operate within them, constrain the ability of the ecosystem leader to alter the ecosystem's governance arrangements as it grows and matures.

THEORETICAL FRAMEWORK

The previous section suggests the need for a more comprehensive framework to explain the ability of an ecosystem leader that controls an apparent bottleneck segment to capture value. In this paper, we aim to integrate the essentials of each line of research presented above to provide this type of a framework. To achieve this, we focus on identifying the initial conditions and processes which create path dependencies over time in the ecosystem and the industry it serves, and which affect the ability of the ecosystem leader to capture an increasing share of the value created by the ecosystem. As mentioned above, the current literature makes no explicit association between the initial conditions of when the ecosystem leader initiated its efforts to create the ecosystem and its subsequent value capture. These initial conditions are 1) the degree to which the focal firm has an established network of suppliers, customers, and complementors, which it can leverage in its efforts to create a vibrant ecosystem, and 2) the life cycle stage of the industry's evolution, the emerging (mature) stage of which is denoted by high (low) growth opportunities, driven purely by technological imperatives, or in part by customer tastes.

Thus, by considering different life cycle stages of the industry served by the ecosystem and the degree to which the ecosystem leader already has an established network of partner organizations that it can leverage, we can think about different scenarios that demonstrate different initial conditions for an ecosystem leader, which in turn will be decisive for its future ability to capture value. We can depict these initial scenarios in Figure 1 below.

---------- Insert Figure 1 here ----------

Before we explain in detail how each quadrant influences the ability of the ecosystem leader to capture value, it is important to clarify how we read Figure 1. We see each quadrant in our framework in Figure 1 as a starting point, i.e., each quadrant does not necessarily signify a fixed and unchanging scenario of ecosystem and industry evolution, but they demonstrate the beginning of a dynamic, path-dependent, and evolutionary process, which may result in the ecosystem leader having different ultimate bargaining power than it did at the beginning (such as in the case of ARM, as we discuss below).

Our main argument in this paper is that occupying an industry bottleneck position may not be sufficient (or necessary) to guarantee a high degree of value capture. The stage of the industry life cycle, and the degree to which the ecosystem leader has access to a network of partners at the time in which it initiates its efforts to create an ecosystem to serve a particular industry, collectively affect the future ability of the ecosystem leader to capture value. For example, an ecosystem leader that aspires to establish its place in an ecosystem as a new entrant will have low initial bargaining power vis-à-vis its prospective ecosystem partners (as it needs to build relationships and a new architecture around its technology and product), which in turn compels it to offer favorable contractual arrangements to these partners. If the ecosystem succeeds in growing and attracting additional participants, these initial contractual arrangements are likely to be a major influence on the increasingly stabilized arrangements offered to, and taken up by, prospective members. The resulting governance inseparability might limit the ecosystem leader's future ability to capture value, even if it occupies a bottleneck position in terms of high complementarity and low factor mobility relative to other parts of the ecosystem, which should, in theory provide it with higher bargaining power. This effect is further pronounced as the industry that the ecosystem serves reaches its maturity, denoting slowed technological progress and demand growth, thus fewer opportunities for ecosystem-wide value creation. In other words, the theoretical mechanism we offer in this paper is that the degree to which a focal firm is already established (in terms of having an existing network of partners to leverage) when it begins its efforts to create an ecosystem affects its future ability to capture value, and this relationship is moderated by the stage of the life cycle of the industry which it serves (see Figure 2 below).

---------- Insert Figure 2 here ----------

Quadrant A) A new entrant in an emerging industry. In this scenario, the focal firm is a new entrant that initiates its efforts to create an ecosystem serving an emergent industry without having existing ties to partners to build on. In the early stages of ecosystem development, firms that struggle to create an ecosystem around their product or service are more concerned about inducing coordination and stimulating value creation among its partners (Gawer and Cusumano, 2002), incentivizing partners to join and invest in the ecosystem (Gawer and Henderson, 2007), and more broadly, designing the 'rules of the game' in the ecosystem (Iansiti and Levien, 2004; Jacobides et al., 2006). As Moore (1993) states, during the birth of an ecosystem 'it often pays to cooperate' (p.76). While early stages of an ecosystem denote a fluid architecture (Jacobides et al., 2006), i.e., less established templates for division of labor ("who does what?") and value appropriation ("who receives what?"); early stages of an industry are characterized by rapid change in customer needs (Adner and Levinthal, 2001) and technological alternatives (Klepper, 1996). This stage of an industry's evolution denotes increasing value captured through exploiting numerous opportunities for value creation, i.e., growing the pie for value created. This can be both from the technology and demand sides.[10] The combination of the rapid pace of growth in improved product characteristics and increasing demand both in quality and quantity of these products gives increasing number of opportunities to the ecosystem leader and its partners to rapidly enlarge the total value created.

ARM's entry into mobile device industry with no established relationships in the semiconductor ecosystem in the 1990s fits into this quadrant. As ARM was starting to establish its position from scratch, their focus was not on squeezing their partners by charging high license or royalty fees. Quite the contrary – ARM was aiming at increasing cooperation with its partners to gain a foothold in the emerging ecosystem and the smartphone industry it served. Another example is Tesla's recent move to open their patent portfolio to initiate the electric vehicle ecosystem. This move has been surprising to most industry followers, however when seen through our framework, Tesla's aim is obvious: to incentivize potential ecosystem partners to flock around their technology portfolio and dominate the emerging electric car industry. The growing demand and supply side opportunities combined with the Tesla not having the relationships with potential ecosystem partners established motivates the company to increase its value capture through growing the total value created and through establishing its dominance in the ecosystem's governance structure, rather than renegotiating 'who receives how much' of the value created.

[10] Most of the classic work on industry evolution (Klepper, 1996; 1997) focuses on the technology side with a particular focus on the knowledge and competences which help firms to capture value from innovations (Di Stefano et al., 2012). However, demand-side theorizing has also been shown to be useful in explaining important aspects of industry evolution (cf. Argyres, Bigelow, and Nickerson, 2013).

Governance arrangements in this case favor partners, rather than the ecosystem leader, as the initial bargaining power of the ecosystem leader is low and the focus is on cooperation and value creation. In the likely event of changes in bargaining power in the future, these initial governance arrangements are likely to limit the ecosystem leader's efforts to renegotiate the governance arrangements in its own favor, resulting in a suboptimal share of the value captured from the ecosystem.

Quadrant B) A new entrant in a mature industry. Quadrant B focuses on a new entrant in a mature industry. In some cases of vertical disintegration the emergence of an ecosystem might coincide with the maturity stage of an industry's life cycle (see e.g. Jacobides, 2005). Setting up governance mechanisms and the architecture of an ecosystem when the industry which the ecosystem will serve is already at its maturity might require a different focus with respect to value capture from the ecosystem leader's perspective. The focus in this case has to be more on value capture at the expense of other partners (competition), as collaborative value creation in the form of growing the total value pie is less of a viable option due to the maturity of the industry. Seen from the lens of Figure 2, this quadrant is the least preferable option to initiate efforts from the ecosystem leader's perspective as a lack of existing relationships with other firms combined with low growth potential of the industry it serves result in disproportionately low initial bargaining power. The governance arrangements made by the ecosystem leader therefore become crucial determinants of their ability to capture value, as the ecosystem leader will be facing the tradeoff between giving away favorable conditions to its potential partners in order to establish the ecosystem and its position in it (cooperation and low initial bargaining power), and capturing a greater share of the stagnant total value created as a result of the decreasing opportunities of the mature industry life cycle stage.

An example of a new entrant trying to establish an ecosystem in a maturing industry is Jolla Ltd., a Finnish smartphone company that developed and launched its own Jolla smartphone and Sailfish mobile operating system in late 2013. In an effort to overcome the disadvantages it faced in starting an ecosystem in this mature and heavily-contested industry, Jolla Ltd. first established an open alliance (the Sailfish Alliance) with a number of partners including retailers, software companies, and digital communities, who can contribute to, and benefit from, the development of the ecosystem. The Sailfish operating system was made available under an open-source license to encourage take-up from manufacturers, while cross-compatibility with Google Android applications and hardware was introduced to extent the appeal of the smartphone and operating system beyond the hardcore of Jolla supporters. These actions are clearly focused solely on establishing the ecosystem, with apparently little attention being given to value capture in either the present or the future, although the Sailfish Alliance website does state that "Jolla is open to discussing revenue sharing or innovative business models together with all of our ecosystem partners" (Jolla Ltd., 2014).

Quadrant C) Established entrant in an emerging industry. Quadrant C focuses on an established entrant in an emerging industry. Here, similar to (related) diversification of a business, an established network of relationships with partners might be used by the ecosystem leader to create an ecosystem serving an emerging industry.[11] Here, the existing relationships of the ecosystem leader may be leveraged to give it greater bargaining power relative to other prospective participants, and allow it to shape the initial ecosystem governance arrangements to its advantage. Seen again from the lens of Figure 2, this quadrant is the most preferable to initiate efforts from the ecosystem leader's perspective as it implies a high initial bargaining power and high growth for the industry it serves. In this case, the high initial bargaining power gives ecosystem leader the option to set up favorable

[11] The implicit assumption we make here is that an existing network of partners might be leveraged, even if it is to some degree only, in the new industry as well.

governance arrangements for itself, which will protect its ability to capture a large share of the value created in the future through governance inseparability, even if it loses its bottleneck position in the future. In this case, being a bottleneck is not a necessary condition to capture a greater share of the value as initial favorable governance arrangements will safe-guard the ecosystem leader's large share of value captured. Possible examples for this quadrant are Apple's successful attempt to create a lucrative ecosystem in the smartphone industry around the iPhone, and our illustrative case, ARM, going into emerging industries other than mobile devices, such as internet of things (IoT) and wearables. In Apple's case, the company already had a well-established base of customers, developers, and other ecosystem partners who were part of its Apple Computer and iPod/iTunes ecosystems. By leveraging its existing design and marketing partnerships and capabilities to successfully launch the iPhone, Apple had relatively little trouble developing a vibrant ecosystem around it despite its closed nature and requirements that complementors pay Apple a significant share of their revenues from iPhone compatible software and hardware. The other example, ARM going into IoT and wearables, is a strategic move of ARM, taken in order to tap into new industries while leveraging its current established ecosystem, especially because the growth of smartphone sales in developed countries is slowing or has even peaked. ARM expectedly leverages its bargaining power and bottleneck position more in these new industries than they were able to do in the emerging phase of the mobile industry, where their nascent position in the ecosystem was less clear.

Quadrant D) Established entrant in a mature industry. As the industry served by an ecosystem matures, the focus shifts from value creation to value capture (Di Stefano et al., 2012; Moore, 1993). Similar to quadrant C, as a result of network externalities due to having numerous partners having joined the ecosystem, the leader's incentives for inducing cooperation and value creation are lower in this quadrant. The ecosystem leader's bottleneck position and architectural advantage might come into play as further growth opportunities are depleted in a mature industry, and the leader may try to use this advantage to set up conditions governing value creation and appropriation in the ecosystem in such a way that it receives a greater share of the value created. However, a maturing industry also means slowing technological growth, thus there are fewer incentives for ecosystem members to invest in updates to the leader's platform, reducing the leader's initial bargaining power to a moderate level.

As the industry reaches maturity, product features that best satisfy customer needs gain traction over time and gradually reach saturation. Further development of products creates the necessary context for disruption to occur (Christensen, 1997; Christensen, Anthony, and Roth, 2004). Christensen et al. (2004) raise the issue of 'customer overshooting', meaning that the incentives for customers to adopt the latest technology decreases over time as customers do not need or cannot utilize the benefits which it provides. Thus, as demand matures over time, firms that push the adoption of newer generations of technology start to experience constrains in increasing the total value created.[12] Pierce (2009) studies niche market of automotive leasing within the brand-based differentiated ecosystems in the automotive industry, where networks of partners surround car manufacturers. Studying efforts by established players to create an ecosystem in a mature industry, he shows that car manufacturers' product design choices have negative effects on value captured by lessors. This case provides a clear example of our quadrant D, where the ecosystem leader leverages its bargaining power as a result of decreasing opportunities for value creation, negotiates governance arrangements, and tries to capture more of the value created by its ecosystem.

Here, it is important to mention the role of governance inseparability in limiting changes to governance arrangements (as a result of future changes in bargaining powers), and

[12] This can reflect a decrease in customer willingness-to-pay for the latest technology. Adner and Levinthal (2001) and Adner and Zemsky (2006) also look at the demand side and discuss the effect of decreasing marginal utility of consumers over time on the evolution of technology and value creation/capturing strategies.

therefore the division of total value created among ecosystem partners. Considered this way, starting an ecosystem as an established player in the mature stage of the industry evolution will be beneficial for the ecosystem leader as it will have moderately high initial bargaining power relative to other ecosystem partners, and it will use this to establish governance arrangements which limit possible future increases in the effective bargaining power of other ecosystem partners. If the opportunities presented by the mature industry are still lucrative enough for other parties to join the ecosystem despite the governance arrangements favoring the ecosystem leader, the inseparability of governance arrangements may make such a situation beneficial for the ecosystem leader's future ability to capture value. Thus even if the ecosystem and the industry it serves evolve in a way that the current literature would denote as detrimental to the leader's ability to capture value, the ecosystem leader may still be able to capture a greater share of value than that which could be expected without taking the initial conditions at ecosystem founding into account.

PROPOSITIONS

We now draw upon our framework to explain the effects of the initial conditions at the point of ecosystem leader's entry on the ecosystem's early governance arrangements (through the leader's initial bargaining power), the persistent aspects of these arrangements as the ecosystem grows and matures, and the effects of this path dependence on changes in the ecosystem leader's ability to capture value.

Entering with an established network of partners and initial governance arrangements. One of the initial conditions that shape the future value capture of the ecosystem leader is the degree to which the focal firm has an established network of partners, which it can leverage in its efforts to create a vibrant ecosystem. Entering an ecosystem with an established network of partners translates into high initial bargaining power for the ecosystem leader, which can be reflected in its ability to enforce protection of its interests in the contractual terms under which the nascent ecosystem operates. Therefore we propose;

Proposition 1a: At the point of its entry, the greater the extent to which the ecosystem leader has an established network of partners, the greater the extent to which the initial ecosystem governance arrangements will include contractual clauses designed to protect the value of the ecosystem *leader's investments in the ecosystem.*

Proposition 1b: At the point of its entry, the greater the extent to which the ecosystem leader has an established network of partners, the lower the extent to which initial ecosystem governance arrangements will include contractual clauses designed to protect the value of the investments in the ecosystem made by other ecosystem members.

Moderator: Industry life cycle stage. The second initial condition that affects the future value capture of the ecosystem leader is the life cycle stage of the industry that the ecosystem serves. If the industry is in the emerging stage of its life cycle, this denotes increasing opportunities for value creation, and therefore the focus of the ecosystem leader and its partners will be on capturing value through rapid growth of the total value created. Therefore we propose:

Proposition 2: The effects proposed in P1a and P1b will be negatively moderated by the life cycle stage of the industry served by the ecosystem. These effects will be stronger if the industry served by the ecosystem is emerging and weaker if it is mature.

Number of ecosystem participants and governance inseparability. As the ecosystem matures, the architecture of it becomes more established and the governance terms under which new members can join the ecosystem become stabilized. Ecosystem's evolution is a continuum, with number of participants being a useful proxy of how developed it is, and more participants mean that more standardized governance arrangements become more useful. As the number of ecosystem participants agreeing to operate under the ecosystem's governance arrangements grows, this constrains the ability of the ecosystem leader to alter the ecosystem's governance arrangements as it grows and matures.

Proposition 3: The extent to which governance arrangements in a mature ecosystem will include similar contractual clauses agreed upon by ecosystem members at its inception will increase with the number of participants that have joined the ecosystem post-inception.

Value capture and governance inseparability. Building on P1a and P1b, the initial bargaining power and initial the governance arrangements made by the ecosystem leader with its partners will have an impact on the future value capturing of the ecosystem leader:

Proposition 4a: The ability of the leader of a nascent ecosystem to capture value when the ecosystem is mature will increase with the extent to which the initial ecosystem governance arrangements included contractual clauses designed to protect the value of the ecosystem *leader's investments in the ecosystem.*

Proposition 4b: The ability of the leader of a nascent ecosystem to capture value when the ecosystem is mature will decrease with the extent to which initial ecosystem governance arrangements included contractual clauses designed to protect the value of the investments in the ecosystem made by other ecosystem members.

Moderator: Change in governance arrangements over time. The initial governance arrangements will matter more for future value capture by the ecosystem leader if they do not change over time, i.e., if the governance inseparability is stronger. Therefore, the extent to which the governance arrangements stay stable as the ecosystem develops, the effect of the initial arrangements on the ability to capture value at ecosystem maturity will be stronger.

Proposition 5: The effects proposed in P4a and P4b will be positively moderated by the extent to which governance arrangements in a mature ecosystem include the same contractual clauses agreed upon by ecosystem members at its inception.

With these propositions, the mechanisms we propose are more clearly put forward. A complete visual model that integrates all mechanisms is proposed in this paper can be found in Figure 3. Now, imagine an ecosystem leader that can have high or low 'initial' bargaining power at its entry into a nascent ecosystem depending on possessing an established network of partners. These initial bargaining power conditions can change in three ways over time; it can increase, stay constant, or decrease (See Figure 4).

---------- Insert Figures 3 and 4 here ----------

If we focus on the evolution of the share of the value captured by the ecosystem leader based on these alternative scenarios, we can map it using the S-curves in Figure 5. Figure 5 summarizes our overall arguments for the evolution of different initial levels of bargaining power and the value captured by the ecosystem leader. First of all, in line with our arguments about industry life cycle, we picture the shape of the total value created by the ecosystem as an S-curve (Agarwal and Bayus, 2002). Assuming no change in the bargaining power, the constant bargaining power lines in Figure 5 show the ecosystem leader consistently capturing a fixed share of the value created by the ecosystem over time.

---------- Insert Figure 5 here ----------

Alternatively, if the ecosystem leader's bargaining power is increasing (decreasing) over time, this will naturally increase (decrease) the share of the value captured by the ecosystem leader. The lines for increasing (decreasing) bargaining power over time in Figure 5 illustrate this case. One thing here is important to mention; if the ecosystem leader's initial bargaining power is low, even if the leader's bargaining power increases over time, its effective bargaining power and ability to capture value from the ecosystem are likely to be lower than the cases for high initial bargaining.

ILLUSTRATIVE EXAMPLE: ARM HOLDINGS PLC

Using our framework, we focus on ARM Holdings PLC (ARM), a UK headquartered semiconductor design firm. ARM's evolution, i.e., the company's early efforts to create the IP niche with perpetual licenses for the emerging mobile computing industry in late 1990s, can be understood better and its low value capturing puzzle can be explained from a theoretical perspective. The emergence and expansion of the IP niche of the semiconductor ecosystem coincides with the emergence of the mobile computing industry (depicted as quadrant A in the upper left part of Figure 1). Also ARM's current ecosystem approach with established relationships in the ecosystem coincides with the maturity of the mobile devices industry in 2014. Therefore, the evolution of how ARM established its position in the semiconductor ecosystem over time and the evolution of the mobile computing industry coincides with each other's early and late stages.

ARM licenses processor designs to its customers (licensees), which licensees use for creating their own central processing units (CPUs).[13] For the licensees, to buy every new generation of ARM's technology means they have to consider the cost of the new license against the remaining useful life of the technology generation which they currently license. Despite the productivity and design time gains from using the old technology (reusing the old technology increases gains from learning economies), it may not be possible to design chips which implement features from the new technology generation by reusing the old technology. This pace of technological growth can only happen when end customers (buyers of end products) are constantly demanding better product features on the demand side, and the rate of processor speed is continuously growing on the technology side. The only phase of an industry when changes in product features is this fast is the emergence and growth phase where customer needs remain fluid (Clark, 1985), technological opportunities are abundant (Klepper, 1996), and the improvements in product features does not yet overshoot the customer needs (Christensen et al., 2004). These together justify ARM's licensees investing and adapting to technological changes faster during its initial efforts, which in turn increases ARM's value capturing through new licenses (i.e., through growing the total value pie). This was part of ARM's growth strategy to establish its position in the emerging ecosystem, and the industry it serves, so ARM was aiming to benefit from cooperative value creation without a concern for competition. Therefore, in line with our argument, in the emergent phase of an industry, the pace of change in the product features on the demand side and the rate of processor speed growth on the technology side offered plentiful value creation and growth opportunities for ARM and its partners.

In ARM's case, low bargaining power relative to initial partners including Apple, Texas Instruments, and Nokia, resulted in these partners being offered perpetual rights as part

[13] Additionally, licensees gain access to ARM's network of partners, as well as ARM's support, allowing them to provide compatible products and services.

of the licensing arrangements, reducing the risk of opportunistic hold-up behavior on ARM's part. As new partners were attracted to the growing ecosystem, ARM likely found itself unable to take perpetual rights off the table for new partners despite its growing influence, as doing so would put new partners at a disadvantage compared to existing ones. These constraints on governance switching grew more binding as more partners joined and benefitted from perpetual rights to design and manufacture chips based on the ARM architecture.[14]

As the mobile devices industry, in particular the smartphones and tablets, is now reaching maturity and technological growth started slowing down, licensees of ARM architecture have the option of not licensing a new technology generation and continuing to develop processors based on the older technology they currently license instead (due to perpetual licenses). In this case, ARM's focus had to change from gaining further new licensees (i.e., value creation) to increasing their royalties (i.e., value capture) to reap the benefits of its already established bottleneck position. These patterns can be seen in Figures 6 and 7 where ARM's revenues increasingly depend on royalties and less on licensing fees over time. The part of royalties that come from mobile licensees is also decreasing. Furthermore, the new licensees are not coming mainly from mobile devices industry, they come from non-mobile ones.

---------- Insert Figures 6-7 here ----------

In ARM's case, the move away from increases in single-core processor speed following 'Moore's law'[15] and towards multi-core processors, which are primarily useful for running multiple applications simultaneously (a capability less essential for mobile devices than for desktop computers) are signals of industry maturity on the technology side. This

[14] While governance switching constraints appear to be an important issue for ARM, it has been able to avoid governance differentiability constraints, as evidenced by the range of licensing deals that it offers to various partners. However, all of these arrangements give the licensee the perpetual rights to manufacture chips based on the technology licensed.

[15] Moore's law states that number of transistors on ICs doubles approximately every two years.

changeover from processor speed-ups to multicore computing is more pronounced as silicon technology, and thus Moore's law, approaches its limits, decreasing the incentives of ARM's licensees to go for the latest technology IP, both on the demand side due to apparent maturity of developed country smartphone markets and on the technology side for natural limits being reached in the dominant design (Complementary metal–oxide–semiconductor (CMOS)) for cutting edge technology. The maturity of the industry also puts pressure on prices, which hurts royalties that ARM receives. While ARM's per-chip royalty rates have generally been pushing up from about 1 percent to 2 percent per core, they are based on the chip sale price, which is under downward pressure in most mobile applications due to maturity of the industry. All in all, due to reasons explained through our theoretical framework, ARM's value capturing from the semiconductor ecosystem is suboptimal, as evidenced also in its lower Return on Invested Capital (ROIC) ratios – a measure commonly used in the literature for value capturing, compared to other significant members of the ecosystem (see Figure 8).

---------- Insert Figure 8 here ----------

CONCLUDING REMARKS

Towards an integrated understanding of value migration in ecosystems. Existing work on ecosystems has highlighted the strategic impact of the structure of relationships between industry participants (Iansiti and Levien, 2004; Adner and Kapoor, 2010; Adner 2012). In particular, research on industry architecture has pointed to the role of bottlenecks as an important determinant of the way value is distributed within an ecosystem (Jacobides, et al., 2006; Pisano and Teece, 2007; Baldwin, 2010; Jacobides and Tae, 2014). However, initial relationships between ecosystem leaders and its partners can have a lasting impact on the degree to which value is captured. By pointing to the importance of governance inseparability (Argyres and Liebeskind, 1999; 2002) and industry evolution (Langlois and Robertson, 1995), we show how ecosystem leaders that occupy a bottleneck position might capture a lower degree of value as than anticipated originally. Such effects become more pronounced as the industry matures, and the focus shifts from value creation to value capture (Di Stefano, Gambardella, and Verona, 2012; Moore, 1993).

Bringing together insights from these literatures, we propose the following explanation for value migration in an ecosystem as it grows and matures. Initially, the ecosystem creator enters into governance arrangements with partners that are primarily designed to incentivize these firms to join the ecosystem. The bargaining power of the creator vis-à-vis its partners determines how much of the value created by the ecosystem the leader is able to capture. As the ecosystem takes off and grows, so does the industry served by it. The position of the ecosystem leader becomes stronger as partners crowd their platform, increasing the complementarity and reducing the factor mobility of its assets, putting the leader into a bottleneck position. As the industry served by the ecosystem grows, the focus of most industry participants is on value creation, meaning that there is little incentive to significantly re-negotiate the governance arrangements, despite the ecosystem leader's increasing architectural advantage. However, as the industry matures the focus of ecosystem participants shifts from value creation to value capture. Importantly, governance arrangements set in the nascent stages of ecosystem development constrain the ability of the ecosystem leader to renegotiate these in order to capture more value due to governance inseparability. Despite their apparent architectural advantage, the ecosystem leader's bargaining power is further compromised by a maturing industry resulting in lower reliance of partners on the leader's technology. Thus, an ecosystem leader's bottleneck position may not translate into superior bargaining power if it had low initial bargaining power at the ecosystem's inception and was therefore obligated to offer initial partners governance arrangements that privileged their value capture prospects over those of the ecosystem creator.

By combining insights from the literature on industry evolution, governance inseparability, and bottlenecks in industry architectures, we can explain why ARM captures only a small share of the value from its ecosystem, despite its apparent bottleneck position. In this particular case, ARM's use of perpetual licensing arrangements, while being important in getting partners on board as a safeguard against hold-up by ARM, restricted their ability to renegotiate governance arrangements as the ecosystem, and ARM's influence, grew. Ecosystem members joining at a later point in time expected similar treatment to existing members, leading to ARM facing governance switching constraints. As the mobile devices industry matured, ARM's ability to alter its licensing terms has been further reduced by the stagnant demand for new generations of its technology from partners interested in selling into the premium smartphone industry. These factors prevent ARM's bottleneck position from translating into bargaining power which would allow it to capture of greater share of the value created by its ecosystem.

In terms of limitations, our framework may apply in particular to settings marked by a high degree of turbulence and interdependence. Therefore, it is not entirely coincidental that our main illustration (ARM), as well as other examples, derives generally from high tech industries. Such settings are typically characterized by a high degree of technological complexity, resulting both in high degree of interdependence between industry participants, as well as rapid rate of technological change as the industry evolves. Finally, future research may test our propositions and consider the boundary conditions to our conceptual framework.

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	Emerging stage of the industry (pre shakeout: high growth of market and industry participants)	Mature stage of the industry (post shakeout: low growth of market and industry participants)
Ecosystem leader is new entrant (no existing relationships with suppliers, customers, and complementors)	A) Ecosystem side: Cooperate – low initial bargaining power and favorable governance arrangements for partners Industry side: Increasing opportunities for value creation – focus on capturing value through rapid growth of the total value created	B) Ecosystem side: Cooperate – very low initial bargaining power and favorable governance arrangements for partners Industry side: Decreasing opportunities for value creation – focus on capturing value through reaping a greater share of the stagnant total value created
Ecosystem leader is established (has relationships with existing network of suppliers, customers, and complementors)	C) Ecosystem side: Compete – high initial bargaining power and favorable governance arrangements for the ecosystem leader Industry side: Increasing opportunities for value creation - focus on capturing value through rapid growth of the total value created	D) Ecosystem side: Compete – moderate initial bargaining power and favorable governance arrangements for the ecosystem leader Industry side: Decreasing opportunities for value creation – focus on capturing value through reaping a greater share of the stagnant total value created

Figure 1. Initial scenarios at time of ecosystem creation

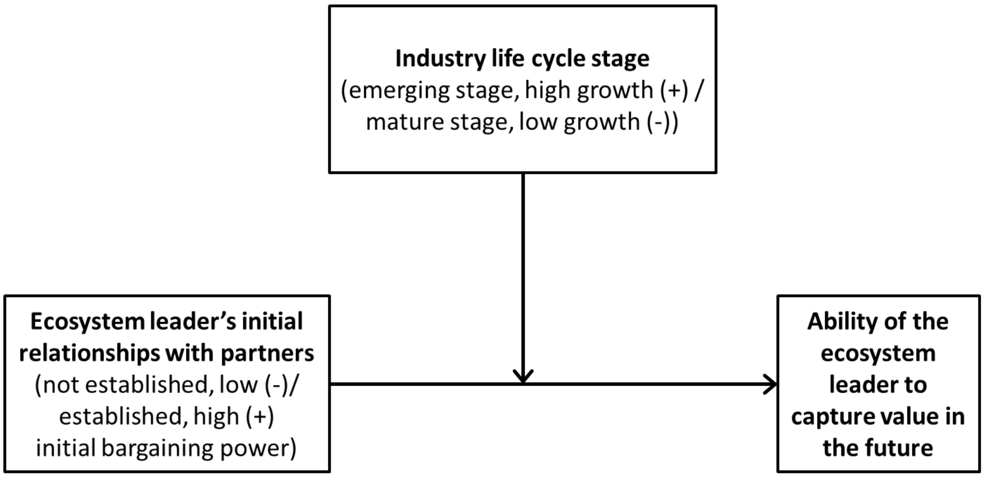

Figure 2. Linking ecosystem and industry life cycles for value capture

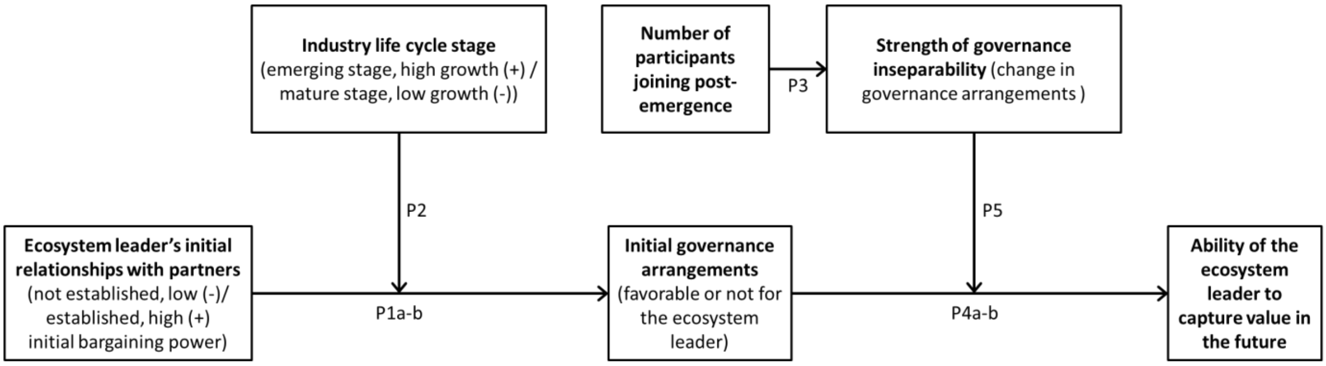

Figure 3. Theoretical model

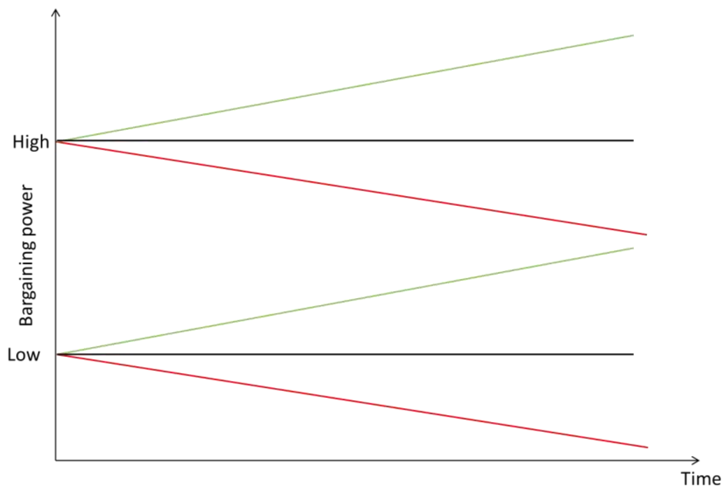

Figure 4. Alternative evolutionary patterns for high and low initial bargaining power conditions

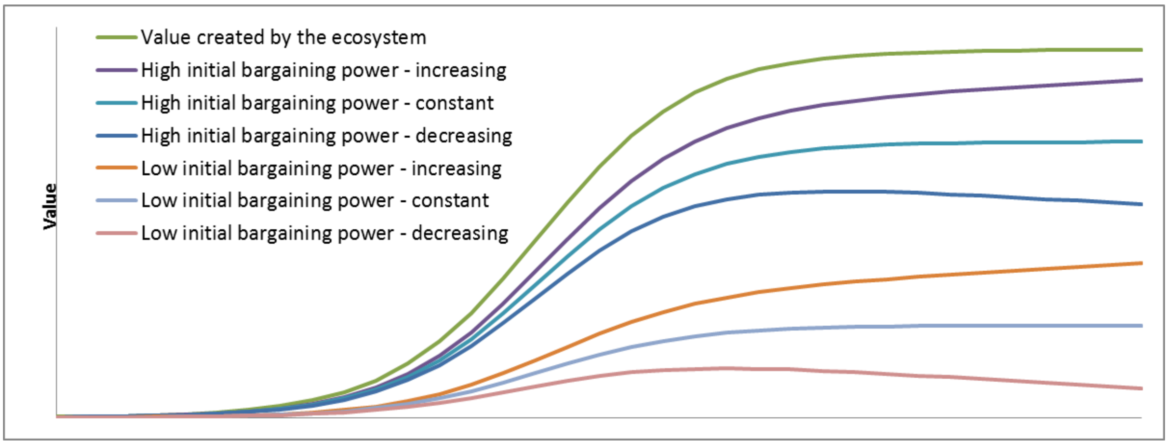

Figure 5. Evolution of value created by the ecosystem and alternative value capturing scenarios for the ecosystem leader with different initial bargaining power (high vs. low) and different evolutionary patterns (increasing, constant, and decreasing)

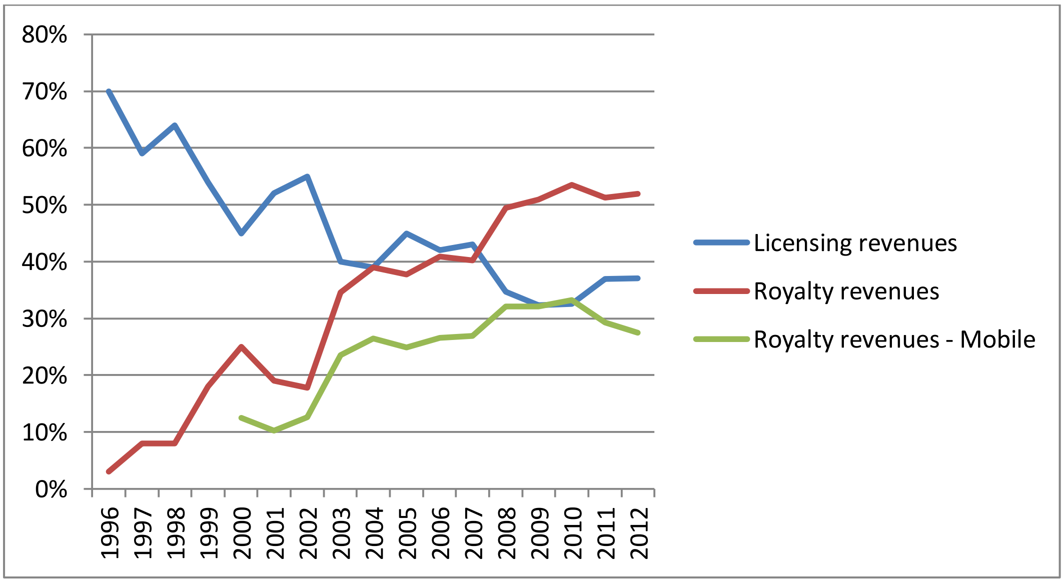

Figure 6. ARM's revenue mix from licensing and royalties (derived by authors from ARM annual reports)

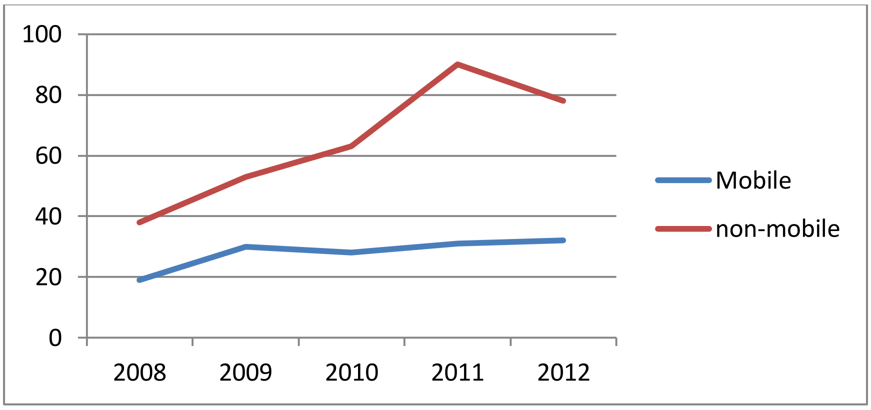

Figure 7. ARM's new licenses from mobile and non-mobile segments (derived by authors from ARM annual reports)

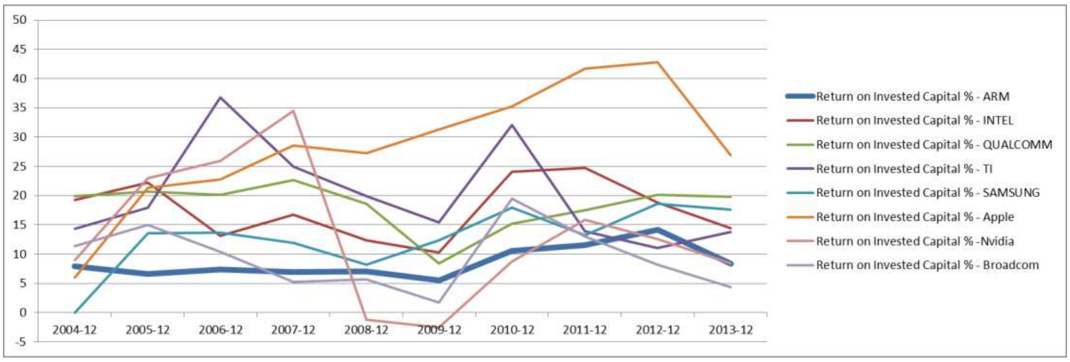

Figure 8. ARM's Return on Invested Capital ratio over years (thick line) compared to other significant firms in the ecosystem