THESIS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY

# Becoming a keystone:

## How incumbents can leverage technological change to create ecosystems

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*To my beloved parents and wife*

ABSTRACT

The proliferation of digital technology and automation in the 21st century has created a need to revisit established theories on value creation. Exponential advances in Internet of Things (IoT) technologies are dismantling firm- and industry-specific value creation processes. The firms developing digital technology-based products and services typically participate in broad networks, which allows them to integrate distinct systems and technologies to produce a focal value proposition. The purpose of this thesis is to explore how incumbents can leverage technological change to create an innovation ecosystem.

The concept of an innovation ecosystem is a powerful analogy to explain value co-creation in a network. In general, ecosystems are broad cooperative networks, in which the actors coalesce organically and co-evolve through the construction of a value proposition. Although several scholars have studied value co-creation in an ecosystem, few have explored the process of ecosystem emergence. Also, extant research on ecosystem primarily investigates orchestration capabilities from the perspective of technology firms or new entrants that emerge within an ecosystem. Few empirical studies investigate how incumbent firms can co-create value and develop capabilities to orchestrate an ecosystem as a keystone actor.

In this context, this thesis investigates a manufacturing firm's efforts to develop a new technology. The research was designed as an ethnographic in-depth case study of Volvo Car Group, an incumbent in the automotive industry. The thesis employs a qualitative abductive research approach to explore the collaborations related to the development of AD technology, a discontinuous technological change for incumbent automotive firms. Based on a four-year longitudinal case study and findings from four papers, the thesis makes important contributions to scholarly understanding of ecosystem emergence in traditional industries.

This thesis makes three main contributions to literature on innovation ecosystems: (1) it describes 'layered modularity' as a design mechanism that facilitates joint value creation leading to the emergence of an innovation ecosystem, (2) it shows how developing physical products (such as devices or hardware platforms) and digital systems (such as IoT technologies or software) in distinct layers allows intertwining of divergent innovation activities and development methods, (3) it distinguishes between three distinct activities – cooperation, coordination and competition – that incumbents firms need to manage in order to become a keystone actor and orchestrate the ecosystem. The findings presented in this thesis have important implications for manufacturing firms looking to leverage a DTC to create new ecosystems.

**Keywords:** Innovation ecosystem, discontinuous technological change, modularity, case study

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Gouthanan Pushpananthan

Göteborg, February 2022

## List of appended papers:

This thesis includes an extended summary of the four appended papers listed below. The papers are referred to in the text by their Roman numerals.

**Paper I**

Pushpananthan, G., Lindlöf, L. and Rothoff, M. (Forthcoming). Tactical capabilities in agile NPD projects: Insights from an autonomous car project in Sweden. *Int. J. Business Innovation and Research.* DOI: 10.1504/IJBIR.2021.10042530

**Paper II**

Pushpananthan, G. and Elmquist, M. (2022). Joining forces to create value: The emergence of an innovation ecosystem. *Technovation* 115, 102453.

**Paper III**

Pushpananthan, G. and Elmquist, M. Keystone orchestration in an emerging ecosystem: The case of autonomous drive technology development in Sweden.

Manuscript under development for 2nd round of review in *International Journal of Innovation Management.*

**Paper IV**

Pushpananthan, G. The battle for keystone position: Exploring the competitive dynamics in an emerging innovation ecosystem.

Working paper under preparation for submission to an international journal (Target journal: *Technological Forecasting and Social Change*).

A previous version of this paper was presented at the CINet conference 2021, September 13-15, 2021(digital conference), Gothenburg, Sweden

**Authors' contributions in co-authored papers:**

Paper I: Pushpananthan took the lead role in the developing the manuscript. Lindlöf was involved in developing the study topic and contributed to sections on agile methods. Rothoff provided important insights on the case firm. Data from Pushpananthan's case study was used.

Paper II: Pushpananthan took the lead role in developing the manuscript, supported by Elmquist. Pushpananthan collected and analysed the data. Both authors contributed equally to developing the findings. Pushpananthan took the lead role during the review process, Elmquist supported in writing and structuring the paper throughout the process.

Paper III: Pushpananthan took the lead role in the writing process. Data from Pushpananthan's case study was used. Elmquist assisted in structuring the manuscript and developing the contributions.

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# 1. Introduction

*This chapter first describes the research area and provides an overview of the research setting, followed by a discussion of the research problem. Following this, the overall purpose and research questions are presented.*

## 1.1. Background

Advances in the development of Information and Communication Technologies (ICTs) such as microprocessors and broadband communication, and access to inexpensive cloud computing is allowing the digitization of most 'functions' and 'features' of industrial-age products such as cars, television, and phones as well as books (Yang et al., 2018). Big data, distributed processing, cloud computing, etc. have led to the convergence of the digital and the physical in the industrial world and has altered the competitive dynamics of industries. Speakers have become smart assistants and mobile phones have extended into full-fledged personal cameras. Thus, the rapid advancements made in ICTs have caused a tectonic shift in the rate of innovation activity. This requires a re-examination of established theories related to value creation and how firms in contemporary digital economy can establish competitive advantage (Cennamo, 2021; McIntyre and Srinivasan, 2017). In recent times, there has been a greater emphasis on the need to look beyond the value chain concept, which for long, dominated the strategic analysis of industries (Lange et al., 2013; Peltoniemi, 2004; Peppard and Rylander, 2006).

In this context, the concept of an ecosystem has become a powerful analogy to explain joint value creation (Hannah and Eisenhardt, 2018; Jacobides et al., 2018; Thomas et al., 2022). Establishing an ecosystem to co-create value can help swiftly dethrone the incumbents in established industries and, in some cases, even alter the very nature of an industry (Adner, 2017; Thomas and Autio, 2013). The examples of Kodak in the 1990s, Nokia in the 2000s, and taxi operators in the 2010s illustrate not just radical product innovations pioneered by single firms, but the pervasiveness of value propositions co-created by a network of actors. Scalable networks of actors, engaged in value co-discovery and co-production of value (see Thomas et al., 2022), are disrupting traditional industries and businesses. Previous research has acknowledged the importance of inter-firm collaborations beyond industry boundaries, which leads to concepts based on organizational ecology.

Moore (1993) is considered the first seminal paper on ecosystems and triggered a still-growing body of work on new ways of organizing inter-firm collaboration. The concept of an ecosystem allows the inclusion of complementors, competitors and other agents coalescing with each other. For instance, the supply chain and value chain concepts do not allow for the assimilation of actors, providing complementary products and services, not bound by hierarchies or contracts (Adner, 2017; Gomes et al., 2018). Thus, the ecosystem approach provides a powerful conceptualization of how joint value is created (Gomes et al., 2020). The central tenet of the ecosystem concept "is an evolving set of actors that interact in order for a focal value proposition to materialize" (Granstrand and Holgersson, 2020, p. 3).

In particular, the concept of innovation ecosystem has been used by scholars to capture the cross-industry and cross-country dynamics of innovation in today's digital economy (see Brusoni, 2013). Simply put, an innovation ecosystem focuses on 'value creation' while a business ecosystem focuses on 'value capture' (see Gomes et al., 2018; Gomes et al., 2020; Adner & Kapoor, 2017). Several authors have rigorously examined the underlying logics of an innovation ecosystem (see Gawer and Cusumano, 2014; Jacobides et al., 2018) and there is a proliferation of scholarly works, beyond the value appropriation logics, examining specialized networks or clusters with the qualifier 'ecosystem', namely: knowledge ecosystems (for knowledge dissemination), platform ecosystems (for platform-based transactions), etc.

Several scholars discuss the mechanisms underlying ecosystems for 'value creation' (i.e., innovation ecosystem) (de Vasconcelos Gomes et al., 2021; Thomas et al., 2022) and some highlight the importance of the leadership or keystone position in an ecosystem. Today, the issue is no longer whether to participate in an ecosystem; rather, it is about how to create an ecosystem and establish dominance over other actors. It has been well documented that being the lead or keystone actor enables the orchestration of the ecosystem to one's own long-term advantage, as evidenced with the success of Google, Apple, Intel etc. The role of a lead actor in the emergence or genesis of an ecosystem has also attracted major managerial attention since 2000 (Dedehayir et al., 2018). In this thesis, 'orchestration' is defined as the 'deliberate and purposeful actions' undertaken by a keystone actor (see Poblete et al., 2022).

So far, most studies focus largely on established ecosystems and the lead firm, labelled as the keystone actor (or orchestrator), without providing much clarity on how ecosystems come into existence (Jacobides et al., 2018; Thomas et al., 2022). The emergence process of an innovation ecosystem is still undertheorized. In relation to the development of an ecosystem, one of the main problems is empirically exploring the process of ecosystem emergence as it is a long-drawn process. Thus, it is important for both scholars and practitioners to understand the process of ecosystem emergence through longitudinal studies, to enable prospective keystone actors to better anticipate challenges and improve the likelihood of success (c.f. Thomas et al., 2022).

### 1.2. Research problem

Several scholars describe value creation and capture in an ecosystem (Adner, 2017; Adner and Kapoor, 2010a; Autio et al., 2016), but few explore the process of ecosystem *emergence* (c.f. (Dedehayir et al., 2018; Thomas and Autio, 2013). Although a 'one size fits all' theory of ecosystem emergence is unlikely, it is important that both scholars and practitioners understand and are able to explain some of the mechanisms underlying ecosystem emergence. This will likely help both public and private actors to better strategize in situations of technological change. So far, management and organizational theorists have not been able to explain clearly how firms build and orchestrate successful ecosystems. Most attempts to understand the 'emergence process' remain incomplete (c.f. (Dedehayir et al., 2018). Perhaps the emergence of an ecosystem is merely serendipitous?

A likely explanation for this gap in our understanding of ecosystem emergence might be that the notion of an ecosystem is rather problematic. Gawer and Cusumano (2014) maintain that the difficulty involved in explaining the creation of an ecosystems is rooted in the ex-post definition of an ecosystem. Thus, the inability to identify and investigate an ecosystem 'before the fact' poses methodological difficulties and reduces scholarly contributions to conceptual models and somewhat vague descriptions of how ecosystems come into existence. At the same time, from established firms to start-ups alike, managerial attention is on building an ecosystem and inclusion of the word 'ecosystem' in business prospectuses and marketing materials has become a semantic necessity in modern business. This underlines the importance of a better understanding of the patterns or regularities in ecosystem emergence.

This thesis explores four important elements, recognized in extant research as important in relation to ecosystems (Thomas et al., 2022) and discusses the related theoretical gaps. First, some have suggested that an ecosystem emerges around a focal value proposition, such as an artifact (Granstrand and Holgersson, 2020); or a platform (Gawer and Cusumano, 2014); or a technology (Zhang and Liang, 2011); or an intellectual property (Holgersson et al., 2018). However, there are very few empirical studies exploring the "collective discovery, sense making and negotiation process" (see Thomas et al., 2022, p. 1) that lead to the establishing of an ecosystem.

Second, Jacobides et al. (2018) suggest that modularity and nongeneric complementarities are important ecosystem underpinnings. However, not all modular products (or platforms) develop into successful ecosystems. Much of the early work on modularity centres around the economies of scale and scope. So how does modularity lead to ecosystem emergence?

Third, it is unclear whether both incumbent firms and new entrants (or start-ups) have similar opportunities and face similar challenges during the ecosystem emergence and whether the type of value proposition (e.g., technology, product, platform) plays a role in the emergence process. Ecosystem scholars tend to study mature ecosystems such as Apple's iOS, but provide few insights into how incumbent firms are able to leverage their existing platforms to orchestrate the emergence of an ecosystem (Altman et al., 2021).

Fourth, little is known about how the actors accumulate the resources and capabilities needed to rejuvenate and renew the ecosystem over its lifecycle. The literature suggests that, at the macro level, the ecosystem lifecycle includes four important phases, namely: birth, expansion, leadership, and self-renewal (or death) (see Dedehayir et al., 2018; Moore, 1993; Thomas et al., 2022). However, at the micro level, the lack of hierarchical governance creates distinctive problems for the central orchestrator or keystone actor. The keystone must acquire legitimacy and acceptance during the early emergence phase, in order to minimize threats, attract participants and expand the ecosystem. Thus, understanding the mechanisms through which prospective keystones access the resources and develop the capabilities to support the scaling-up and expansion phases, could provide a better understanding of how ecosystems become established.

### 1.3. Purpose and research questions

Technological change creates both opportunities and challenges for incumbents in an industry, yet we still know little about how incumbents relate to technological change. As many incumbents are faced with such change, there is a need to examine value creation activities to understand why and how they interact with actors from diverse industries during a DTC. **The purpose of this thesis is to explore how incumbents can leverage technological change to create an innovation ecosystem**.

This thesis expunges some of the inconsistencies regarding the emergence process of an ecosystem by studying the activities of an incumbent firm during a DTC. Three research questions will be used to guide the research:

RQ1: How do incumbents create value during a period of DTC?

RQ2: How does modularity influence the emergence of an innovation ecosystem?

RQ3: How can an incumbent firm orchestrate the emergence of an innovation ecosystem?

At the time of writing, the automotive industry was considered widely as the next industry, after Personal Computers (PCs) and cell phones, that would experience a major shift in the organization of its value creation activities, with a move from intra-industry ‘value chains’ to cross-industry ‘value networks’ or ‘innovation ecosystems’. This transition can be expected as largely due to a Discontinuous Technological Change (DTC), with the dominant design for vehicles shifting from Internal Combustion (IC) Engines and manual control, to Battery-Electric Vehicles (BEVs) and Autonomous Driving (AD). Thus, the automotive industry was identified as a relevant context to investigate the impact of new technologies on incumbent firms in traditional industries.

# 2. Theoretical background

*This chapter presents an overview of literature that relates to technological change, value creation, ecosystems, and innovation ecosystems. At the end, some important terms and concepts related to main topic of this thesis are discussed.*

### 2.1. Discontinuous technological change and innovation

A firm's survival is based on its ability to create more value than its competitors (Porter, 1980). Innovation both shapes the industry and determines which firms are winners and which are losers (Utterback, 1994). Previous research suggests that the invasion of a new technology follows a predictable trajectory, based on the process of variation, selection and retention (Nelson and Sidney, 2005; Pinch and Bijker, 1987). Thus, technological discontinuity leads to a period of turmoil – an era of ferment – which leads, in turn, to intense competition amongst the variations before the selection of a dominant configuration (Anderson and Tushman, 1990; Lambe and Spekman, 1997). The established dominant design then becomes the standard architecture that is subjected to incremental improvements until a further technological disruption leads to a new cycle of variation, selection and retention. Thus, technology is a major component of innovation success and survival of incumbent firms. Along with technology, markets play an equally important role. One good example is the qwerty keyboard whose high market penetration has enabled its continued dominance. The influence of technology and market factors needs to be understood in conjunction with human factors such as organizational competence and core capabilities (Pinch and Bijker, 1987). The ability of management to align core capabilities with new technologies and products is of prime importance to compete in a turbulent environment (Utterback, 2004).

Historically, Technology and Innovation Management (TIM) scholars have studied discontinuous innovation as an environmental-level phenomenon (Reid and De Brentani, 2004). TIM studies, from an organizational ecology perspective, suggest that organizations seldom change unless seemingly random events – such as emergence of new technology – trigger periods of change and deviations from the existing trajectory (Reid and De Brentani, 2004). The entry of a new technology in an established industry initiates a period of DTC (Lambe and Spekman, 1997). The established technology might offer performance and cost advantages compared to the invading technology. However, once adopted by the majority of users, a successful new technology will achieve better performance than the established technology which has likely been subject to slow, incremental improvements (Christensen and Rosenbloom, 1995; Utterback, 1994). Not all new technologies obscure the old technology and, in certain cases, they may forge a symbiotic relationship which makes both stronger (Utterback, 2004). Two such examples are razor blades and wet shaving and electric razors, and viewing films at home[1] (using DVDs) or as movies in cinemas – in both cases, the new and old technologies are complementary and equally successful (Utterback, 2004).

Several scholars point out that a period of DTC is related to high levels of uncertainty and entry of new competitors which motivates the incumbent firms to establish technology-sourcing alliances (Corso and Pellegrini, 2007; Lambe and Spekman, 1997). Table 1 presents two examples of a DTC, described by Lambe and Spekman (1997). In example 1, vacuum tubes were replaced by transistors and provided new performance advances for developing electronic products, although, subsequently, transistors were replaced by integrated circuits. In example 2, all three technologies co-exist, albeit the prevalence of the older technologies has decreased, that is, despite the prevalence of on-line banking, ATMs and credit cards still exist.

**Table 1**. Examples of discontinuous technological change (Source: Lambe et al., 1997)

| | **Example 1** | **Example 2** |
|---|---|---|
| **DTC 1** | Vacuum tubes | Credit cards |
| **DTC 2** | Transistor | ATMs |
| **DTC 3** | Semi-conductor | On-line banking |

In example 1, each new DTC made the previous technology obsolete. In example 2, the new technology provided some improvements, but did not result in a complete shift in the technology landscape. Generally, a DTC poses a threat to the incumbent firms and motivates management to renew core technologies, products and processes to keep abreast of the competition (Lambe and Spekman, 1997). Further, scholarly works on DTC have clustered distinct types of technologies[2], such as product technology, process technology and management technology (Atuahene-Gima, 1993; Lambe and Spekman, 1997). Here, a product technology comprises a set of ideas within the product, a process technology includes the ideas involved in the manufacture of the product, and a management technology includes the knowledge required to market the product.

A DTC dramatically changes the industry and creates severe problems for incumbents which need to acquire new competences and defend themselves from new competitors. An important limitation of this reasoning, i.e., incumbents disrupted by new entrants, is that not all incumbent firms fail due to a DTC. As shown in Table 1, the banks survived the technological change from credit cards to on-line banking. However, the firms that specialized in manufacturing

[1] Although DVDs have now become obscure, it is due to the invasion of streaming platforms and digital services. Before the widespread adopting of streaming services for home video, DVDs and cinemas co-existed (see Utterback, 2004, p.85)

[2] In this thesis, technology is interpreted broadly to include product technology, process technology and management technology. This type of broad interpretation of technology is widely used by TIM scholars (see Lambe et al., 1997; Atuahene-Gimme, 1993).

vacuum tubes did not survive the technological change in their industry. There is also much debate surrounding DTC in relation to where the 'discontinuity' occurs. To this point, Lambe and Spekman (1997) suggest that the invention of automobiles introduced a new product life-cycle. In this context, radial tyres represent a discontinuity in the automotive life cycle.

During a technology shift, some incumbents survive and prosper, but some fail (Tripsas, 1997). The survivors are quick to leverage the new technology to maintain their leadership positions; others may take years to gain dominance in the new technology (e.g., Apple which achieved leadership in the PC industry after being on the verge of bankruptcy). The literature often identifies technology as the main reason for firm success or failure. While a shift in the technological landscape may lead to an industry shake-out, incumbent failure depends on much more than the technology per se and includes lack of foresight, unwillingness to share profits, path dependence, etc. (e.g., Anderson et al., 1990; Suárez et al., 1995; Teece et al., 1997; Tripsas, 1997; Utterback, 1994).

In today's digital economy, alliances aimed at technology acquisition and commercialization are increasing. Already in the 1990s, scholars were arguing that technology sourcing alliances cover a wider spectrum than core R&D-related technology (Atuahene-Gima, 1993; Lambe and Spekman, 1997). Increasingly, firms use alliances to acquire critical technology in industries facing a DTC. In this case, cooperation between an incumbent and a firm with new technology competences is the most likely scenario among firms with the capabilities to use the new technology. Discontinuous innovations are usually introduced by new entrants to an industry, but this does not mean that incumbents do not survive.

## 2.2. The process of value creation

In today's knowledge economy, perhaps the most pertinent question in this context is: what is 'value' and how is it created and captured? (Bowman and Ambrosini, 2000). Several scholars have studied the concept of value creation at both the microlevel (individual, group) and the macrolevel (organization theory, strategic management) (see Lepak, Smith and Taylor, 2007). Early work in the management and organization literature, tends to focus on value creation, which, management scholars would agree is an important concept. According to Lepak et al. (2007, p.180), "there is little consensus on what value creation is or on how it can be achieved." Thus, scholars do not uniformly agree what value creation is, or how it is created and captured.

### *2.2.1. Perspectives on value creation*

The multidisciplinary in the field of management results in significant divergence in terms of who creates value and for whom it is created. Human resources management and organizational behaviour scholars focus on creating value for individual employees, employee groups or teams, and organizations. Sociologists and economists focus on creating value for society or nations. Strategic management, marketing and entrepreneurship scholars focus on creating value for stakeholders, business owners and customers (see Lepak et al., 2007). According to Lepak et al. (2007) 'value' refers to the quality of a product, service or task as perceived by users. Scholars acknowledge that the perception of what is of 'value' is subjective and individual specific (Bowman and Ambrosini, 2000). Also, the proliferation of digital technologies has altered the meaning of value and the process of value creation (Prahalad and Ramaswamy, 2004).

Thus, value creation depends on the target user's subjective assessment of value (Bowman and Ambrosini, 2000). The subjective value realized is assessed based on the user's willingness to exchange a monetary amount for the value received (Bouncken et al., 2020). To assess the value created, Lepak et al. (2007) suggest two economic conditions. First, that the monetary exchange must exceed the producer's costs (in terms of money, time, effort, etc.). Second, that the monetary amount offered by the user is a function of the perceived performance. This means that the firm's propensity to engage in value creation, related to new products, technologies or services, is contingent on the potential for its value capture (Bouncken et al., 2020). Lepak and colleagues suggest that new value creation depends on the target user's subjective perception of the novelty of the product, service or task: the greater the novelty, the greater the value to the user. The level of analysis, the source of the value and the theoretical perspective of a particular field are likely to influence identification of the value created and how it is perceived as valuable (Lepak et al., 2007). An overview of various perspectives on vaue creation is provided in Table 2.

**Table 2.** Overview of various perspectives on value creation (Source: Adapted from Lepak et al. 2007)

| Level of analysis | Target or user of value | Value creation process | Academic field | Article |
|---|---|---|---|---|
| Individual | Individual employees, teams | Motivation, training, knowledge creation | Psychology, Human resource management | Lee et al. (2007); Ucbasaran et al. (2013) |
| Organization | Consumer, society | Invention, innovation, knowledge creation, R&D | Strategic management, organizational theory | Porter (1985); Crossan and Apaydin (2010); Anand and Khanna (2000) |
| Society | Individuals, organizations, governments | Capital investment, new venture creation, competition, regulations, and incentives | Sociology and economics | Lee et al. (2007); Lundvall (2007) |

### *2.2.2. Value chain*

The concepts of value chain and value chain analysis focus on the ways in which firms may configure their primary and support activities, to maximize and sustain competitive advantage (Lepak et al., 2007; Porter 1985). In the 1980s, Michael Porter popularized the concept of value chain, and which has been widely employed to understand the complex and distinct activities that occur in business environments. The factors of production in an industrial economy consist of sequential linked activities, in which each actor adds value to the received input before it passes downstream to the next actor. For this reason, the idea of a 'chain' has been used to investigate value creation in traditional industries. The notion of value chain suggests an ordered sequence of activities and has enabled an understanding of the functioning of traditional industries churning out physical products (Allee, 2000; Remneland-Wikhamn et al., 2011).

The traditional understanding of value creation is rooted in an industrial economy model in which each actor occupies a position along a 'linear' value chain (Normann and Ramírez, 1993). It has mainly been used to describe the functioning of traditional industries that produce physical products (Allee, 2000; Lange et al., 2013), and explains the linking between the activities occurring within an industry (Peppard and Rylander, 2006). However, in the current digital economy, value creation activities spread beyond the boundaries of the single firm or industry and, increasingly, involve joint efforts, involving firms across both industries and countries (Linden et al., 2009; Normann and Ramírez, 1993). The shift in the fundamental value creation logic is mirrored in scholarly discourse. In a digitalized economy, as products and services become dematerialized, the physical dimensions of the value chain lose their relevance (Breuer and Lüdeke-Freund, 2017; Remneland-Wikhamn et al., 2011).

It is becoming increasingly rare for firms to operate merely in a linear value chain; they are more likely to co-produce value with multiple economic actors such as suppliers, customers, partners and even competitors. This requires traditional ways of analysing competitive advantage to be revised (Porter, 1980). The value chain concept is becoming redundant due to the digitalization of products and services (Peppard and Rylander, 2006) and the development of new products and services, pioneered by a network of firms from a range of different industries.

### *2.2.3. Value networks*

The notion of a value 'chain' is being complemented by the idea of a value 'network' in which value creation no longer depends on a chain of a fixed set of activities (Normann and Ramírez, 1993; Peltoniemi, 2004). The value chain approach suggests an ordered sequence of activities whereas a network approach involves multidimensional linkages (Adner and Kapoor, 2010b; Peltoniemi, 2004). In value networks, value is created by groups of firms that combine their skills and assets, leading to recombination of capabilities in a network of firms (Clarysse et al., 2014; Galunic and Eisenhardt, 1996; Galunic and Eisenhardt, 2001). Increasingly, firms work closely with customers, competitors and other actors to co-create value (Normann and Ramírez, 1993). According to Breuer and Lüdeke-FREUND (2017, p. 4), "Increasing technological complexity and innovation speed are major drivers of the emergence of value networks."

**Table 3.** Overview of the key literature on value chain and value network (Source: author)

| | Author (year) | Main discussion |
|---|---|---|
| **Value chain** | Porter (1985) | "Every firm is a collection of activities that are performed to design, produce, market, deliver, and support its product. All these activities can be represented using a value chain. A firm's value chain and the way it performs individual activities are a reflection of its history, its strategy, its approach to implementing its strategy, and the underlying economics of the activities themselves" (p. 51-52)<br><br>"A firm's value chain may differ in competitive scope from that of its competitors, representing a potential source of competitive advantage." (p.50) |
| | Normann and Ramirez (1993) | "…every company occupies a position on a value chain. Upstream, suppliers provide inputs. The company then adds value to these inputs, before passing them downstream to the next actor in the chain, the customer (whether another business or the final consumer)" (p. 1) |
| | Möller and Rajala (2007) | "Porter (1985) used the value chain concept to primarily to refer to the firm-level activities through which a firm products value for its customers Value" (p. 898) |
| **Value network** | Allee (2000) | "A value network generates economic value through complex dynamic exchanges between one or more enterprises, its customers, suppliers, strategic partners, and the community" (p. 37) |
| | Peltoniemi (2004) | "…[value ] chain refers to sequential flow while a network implies multidimensional connectedness." (p. 3) |
| | Peppard and Rylander (2006) | "The value chain is underpinned by a particular value creatinglogic and its application results in particular strategic postures. Adopting a network perspective provides an alternative perspective that is more suited to New Economy organisations, particularly for those where both the product and supply and demand chain is digitized." (p. 128) |

Contemporary value creation thus requires the input of more than single firms or single industries and involves close working with customers, competitors and other actors to co-create value (Normann and Ramírez, 1993). . Studies based on value networks often discuss value creation in inter-organizational networks and rarely distinguish between value networks and other network-based concepts (see Table 3). Networks have been associated with new ways of creating value through strategic alliances and co-opetition (Breuer and Lüdeke-Freund, 2017). Complex system technologies, such as smartphones, aircraft, etc., tend to be developed within inter-organizational networks, which reduce the development costs and uncertainty involved in innovation (Lange et al., 2013). However, articles referring to these concepts often discuss creating value in inter-organizational networks with little to no substantial distinction between value networks and other network-based concepts.

The literature on value creation in networks does not distinguish clearly among associated concepts such as innovation ecosystems, innovation networks and innovation systems. According to Prahalad and Ramaswamy (2004, p.5), "informed, networked, empowered, and active consumers are increasingly co-creating value with the firm". Numerous concepts related to value co-creation have emerged (Saarijärvi et al., 2013) and include involvement of a broad range of theoretical perspectives, which makes their rigorous analysis more difficult. According to Adner (2006, p.2), concepts such as value networks, ecosystems and open innovation provide a powerful means of understanding joint value creation. A distinction of between value networks and ecosystems, is the inclusion of complementors and competitors (de Vasconcelos Gomes et al., 2021). Among the various network-based concepts, the use of *ecosystem*, a term borrowed from ecology, in a business or industry context has grown exponentially over the last decade (see Kapoor, 2018, p.2). One aspect related to ecosystems as opposed to value networks is the inclusion in the form of complementors and competitors (de Vasconcelos Gomes et al., 2021).

## 2.3. The concept of ecosystem

In general, an ecosystem is a metastasised concept from ecology with 'eco' referring to the relation of living things to their environment and the system referring to organized body (Durst and Poutanen, 2013). The ecosystem approach was originally introduced into the social sciences field by sociologist Amos Hawley (see Kapoor, 2018) and was applied to adapted to the field of business strategy by Moore (1993) to describe a network of actors characterized by interdependence and co-evolution (Scaringella and Radziwon, 2018). Use of the term 'ecosystem' in the context of co-production of value, has increased since the late 2000s (Kapoor, 2018; Scaringella and Radziwon, 2018) and, now, is used in a range of research areas including strategic management (Adner, 2017; Adner and Kapoor, 2010b; Jacobides et al., 2018b; Teece, 2007; Zhang et al., 2007), innovation management (Clarysse et al., 2014; Gawer and Cusumano, 2014), and marketing (Aarikka-Stenroos and Ritala, 2017).

### *2.3.1. Defining an ecosystem*

An ecosystem consists of a network of individual firms that contribute their individual solutions to a common platform (a value proposition or an artifact), in order to offer a complex value proposition (Adner and Kapoor, 2010b; Clarysse et al., 2014). According to Thomas and Autio (2018), ecosystem participants are embedded in a complex set of network relationships where the value proposition is a combination of the offerings of each participant. Due to the "relative absence of customized, 1-to-1 supplier contracts to define, ex ante, delivery obligations and rewards for different participants", ecosystems are not typified by hierarchical relationships (Thomas et al., 2022, p. 1). Instead, they rely on mutual dependence among participants, role definitions and technological architectures to jointly create value (Adner, 2017; Jacobides et al., 2018; Thomas et al., 2022).

Altman et al. (2021) suggest using the concept of ecosystem as a framework to understand the actors that engage with external communities to create and capture value. In traditional value chains, actors' activities are organized in a hierarchical buyer-seller relationship (Peppard and Rylander, 2006). However, in an ecosystem, value is created within a network of shared assets, interfaces, and standards (Dattée et al., 2018; Jacobides et al., 2018), which involves simultaneous rather than sequential creation and delivery of value by all the actors. Thus, the concept of ecosystem, as an analogy to illustrate value creation and value capture, spanning a range of industries, is well known for its unique characteristics such as serendipitous co-evolution, simultaneous cooperation and competition amongst participants and the importance of both the production and the use sides (see Autio and Thomas, 2016). To create value for end customers, requires an ecosystem to integrate complementary solutions developed by interconnected, but independent actors (Dattée et al., 2018).

Ecosystems have been studied from several perspectives and in different contexts. In extant research, ecosystems are studied from the perspectives of the focal firm or the focal artifact (Adner, 2017; Granstrand and Holgersson, 2020). Most works explore the dynamics between the focal actor and the other actors in the ecosystem (Iansiti and Levien, 2004b). However, it can be difficult to measure and map an ecosystem. One of the problems inherent in ecosystems is its demarcation; the degree of involvement of cooperation and competition within a network is rarely unaddressed. However, it is important that both scholars and practitioners understand the collaborative and competitive dynamics in the ecosystem.

### *2.3.2. Boundary setting and delineating an ecosystem*

The boundaries to ecosystems are difficult to define (Foguesatto et al, 2021; Brusoni, 2013) and mapping the extent of an ecosystem is somewhat haphazard. Some scholars delineate an ecosystem by investigating a particular platform (Gawer and Cusumano, 2014) or technology (Adner and Kapoor, 2016) or any other artifact (Granstrand and Holgersson, 2020). In addition, extant research suggest that an ecosystem 's life cycle consists of distinct phases (e.g. Dedehayir et al., 2018; Moore, 1993), and yet other studies focus on ecosystem strategy (e.g. (Iansiti and Levien, 2004b), ecosystem orchestration (Furr and Shipilov, 2018; Valkokari et al., 2017) and uncertainty management (e.g., Gomes et al., 2021) etc.

According to Reeves et al. (2019, p. 1), "There is no measurable, standard definition of an ecosystem", which implies absence of a definitive description of and boundary to an ecosystem. Instead of defining what is and what is not an ecosystem, Reeves and colleagues focus on "multicompany systems" with characteristics such as large numbers of partners, diversity of industries, relationships based on collaboration rather than partnering. Thus, the boundary to (or the extent of) an ecosystem may be contingent on the type of value proposition in question and the type of system, that is, whether it is a platform, an actor or a technology.

This suggests that attempts to identify the borders to this continuously evolving system would be futile. Some scholars have criticized the concept of ecosystem as lacking rigour and have condemned the evolutionary logic underpinning the ecosystem concept. Oh et al. (2016) argue that an 'ecosystem' in an industrial setting is anything but evolutionary since it is a designed system. However, scholars such as Aarikka-Stenroos and Ritala (2017, p. 25) state that the "the evolutionary logic examines the system-based features of constant dynamism and evolution, as well as the inherent interdependence of the actors involved." Scholarly attempts to provide more clarity and reasoning to the concept have led to more nuanced concepts, focused on different areas of inter-organizational relationships, and, in turn, have led to multiple new conceptualizations.

#### *2.3.3. Ecosystem typologies*

The ecosystem analogy has been extended to include diverse aspects of network-based interactions. In an innovation context, subconcepts have been developed to distinguish between 'value creation' (i.e., innovation ecosystem) and 'value capture' (i.e., business ecosystem) (see Adner, 2006; de Vasconcelos Gomes et al., 2021; Li, 2009; Zhang and Liang, 2011). In other areas, concepts such as 'platform ecosystem' (Ceccagnoli et al., 2012; Gawer et al., 2014), 'knowledge ecosystem' (Clarysse et al., 2014; van der Borgh et al., 2012), and 'entrepreneurial ecosystem' (Pankov et al., 2021) have gained traction since the 2000s.

This thesis does not discuss the reasoning underlying for these typologies of ecosystem; this is addressed in detail elsewhere (see Granstrand and Holgersson, 2020; Jacobides et al., 2018; Scaringella and Radziwon, 2018). Rather, it explores innovation activities and, especially, value co-creation, in an ecosystem comprised of diverse sets of participants (see Saarijärvi et al., 2013), building, primarily, on the literature on innovation ecosystems and platform ecosystems.

### 2.4. Innovation ecosystem

The notion of an innovation ecosystem as a set of "heterogenous" actors that jointly create value, in a network that enjoys self-governance and self-sufficiency, has gained popularity in the fields of organizational strategy and innovation management (Adner and Kapoor, 2016; Thomas et al., 2022). Jackson (2011, p. 2) defines an innovation ecosystem as the set of "complex relationships that are formed between actors and entities whose functional goal is to enable technology development and innovation." Several scholars examine the role of complementarities and evolutionary dynamics. For instance, Granstrand and Holgresson (2019, p.3) state that "An innovation ecosystem is the evolving set of actors, activities, and artifacts, and the institutions and relations, including complementary and substitute relations, that are important for the innovative performance of an actor or a population of actors." Thus, the innovation ecosystem enables the actors to access resources and complementary assets that are beyond the scope and capabilities of a single firm (Adner and Kapoor, 2010; Gawer and Cusumano, 2014; Iansiti and Levien, 2004; Kelly, 2015).

According to Adner (2006), firms collaborate in an innovation ecosystem in order to combine their individual offerings to provide a coherent solution. Thus, innovation ecosystems epitomise joint value creation, involving a group of actors co-creating value through complex dynamic exchanges (Saarijärvi et al., 2013; Williamson and De Meyer, 2012a). Management scholars refer to innovation ecosystem to capture the complexity of innovation activities that span industry and national boundaries (Adner and Kapoor, 2010; Brusoni and Prencipe, 2013) and discuss value co-creation, predominantly, using the concepts of innovation ecosystems and platform ecosystems (Thomas et al., 2022). Also, extant literature on innovation ecosystems is associated with similar concepts such innovation networks and innovation systems, as summarized in Table 4.

**Table 4.** Overview of key literature on organizational forms of innovation in network (Source: author)

| | **Author (year)** | **Main discussion** |
|---|---|---|
| **Innovation system** | Lundvall (1992) | Actors and networks that produce value in a country or region. Firms are embedded in socio economic systems in which culture and politics along with economic policies, determine direction, scale and success of innovation activities. |
| | Cooke et al. (1997) | Regional level systems that promote learning and innovation |
| **Innovation networks** | Dhanaraj and Parkhe (2006) | "Innovation networks can often be viewed as loosely coupled systems of autonomous firms." p. 659<br>"Innovation networks thrive as organizational forms when the sources of industry expertise are widely dispersed and the knowledge base is complex and expanding (Powell et al. 1996)." (p. 661) |
| **Platform ecosystem** | Gawer and Cusumano (2014) | How firms manage platform-related completion. A dominant platform can be built by careful management of ecosystem relationships that are beneficial for all participants. |
| | Thomas et al. (2014) | The platform ecosystem views platform as a hub or central point of control within a technology-based business system. |
| | Shi, Li and Chumnumpan (2021) | "Innovation platforms focus on the purposefully designed technological foundation that can facilitate complementors with specialized expertise in developing complementary innovation outputs." (p. 2040) |

**Table 4. (cont.).**

| | **Author (year)** | **Main discussion** |
|---|---|---|
| **Innovation ecosystems** | Engler and Kusiak (2011) | "The ecosystem is considered as an environment in which the individual agents (innovation entities) exist and interact.<br>The interaction of the agents is with the other agents in the ecosystem as well as the dynamic environment itself." (p. 55) |
| | Mercan and Goktas (2011) | "System approach do not explain relationship between innovation event and innovation structure. Due to the static nature of innovation systems model, innovation which has a dynamic nature should have been analyzed in a convenient framework." (p. 103)<br><br>"Ecosystems and ecologies are the concepts that describe evolutionary features of the interactions between individuals and their relationship with innovation activities and the environment in which they operate." (p. 103) |
| | Ritala and Almpanopoulou (2017) | "In innovation ecosystems, which comprise numerous actors in different layers, actor's decisions may cause counter-responses<br>from other actors. This behavior is multiplied in complex interdependencies across the ecosystem." (p. 39) |
| | Aarikka-Stenroos and Ritala (2017) | "Innovation ecosystems differ from business ecosystems in that they are characterized by innovation-driven goals and related uncertainties over value creation and capture." (p. 25) |
| | Granstrand and Holgersson (2020) | "An innovation ecosystem is the evolving set of actors, activities, and artifacts, and the institutions and relations, including complementary and substitute relations, that are important for the innovative performance of an actor or a population of actors" (p. 3) |
| **Business ecosystem** | Iansiti and Levien (2004) | Includes firms that fall outside the traditional value chain of suppliers and distributors. All firms coordinate to support value appropriation. |
| | Mäkinen and Dedehayir (2012) | "The business ecosystem describes the network of firms, which collectively produce a holistic, integrated technological system that creates value for customers." (p. 1)<br><br>"In addition to firms such as suppliers, complementors, and system integrators, business ecosystems may also be seen to constitute distributors, advertisers, finance providers (e.g. venture capitalists, corporate investors, investment bankers, and angel investors), universities and research institutions, regulatory authorities and standard-setting bodies, the judiciary, and customers" (p. 1-2). |

The interactions within an innovation ecosystem are typically organized around a modular platform consisting of shared assets, standards and interfaces (Dattée et al., 2018). The platform provides the foundations for the development of complementary products and services (Cusumano et al., 2002; Gawer et al., 2014; McIntyre et al., 2017). Thomas et al. (2022) treat “platform ecosystems” as a sub-set of “innovation ecosystems” based on the coordination facilitated by the central platform. The literature provides some rigorous investigations of the logics underlying innovation ecosystems. Several scholars have tried to define innovation ecosystem to distinguish it from other concepts such as innovation systems or innovation networks, for instance see Table 4. See among others, the reviews by (Adner, 2006; Dedehayir et al., 2018; Gobble, 2014; Ritala and Almpanopoulou, 2017; Scaringella and Radziwon, 2018).

### 2.5. Keystone firm in an ecosystem

The word ‘ecosystem’ symbolizes autonomy and self-governance. However, although it might seem paradoxical, management scholars are unanimous in acknowledging that ecosystems for value co-creation need a keystone or lead actor (Adner, 2006; Donada, 2018; Gawer and Cusumano, 2014; Iansiti and Levien, 2004a). Thus, research recognizes the significance of the keystone (or lead) actor in orchestrating the ecosystem (Poblete et al., 2022). Altman et al. (2021) explain that the ‘locus of activity’ in an ecosystem is outside the lead firm’s boundary, but that the ‘locus of control’ remains with the lead firm. Scholarly works on ecosystems focus, overwhelmingly, on the activities of the central actor (Adner and Kapoor, 2016; Cusumano and Gawer, 2002; Dedehayir and Seppänen, 2015; Gawer and Cusumano, 2008; Gawer et al., 2002).

A firm’s resources and capabilities determine its role in the ecosystem and its relationship with other actors (Iansiti et al., 2004). Not all actors occupy the same roles or perform the same sets of activities (Dedehayir et al., 2018; Wulf et al., 2017). Several scholars attribute the development of an ecosystem to a keystone firm (an ecosystem leader, a focal or hub firm) that orchestrates the various activities in the ecosystem (Dedehayir et al., 2018; Iansiti et al., 2004; Moore, 1993; Wulf et al., 2017). Moore (1993) states that the position of ecosystem leader is important to encourage cooperation amongst the actors and protect the ecosystem from external threats.

In practice, firms that aspire to manage or orchestrate the ecosystem – as de-facto leaders or keystones, are likely to face fierce competition with other actors and that these problems intensify as the ecosystem grows and becomes more successful. Several studies have shown that most ecosystems fail. An analysis of 57 ecosystems, in various sectors and across geographies, found that less than 15% enjoyed long run success (Reeves et al., 2019).

The keystone actor is considered the ecosystem caretaker, responsible for ensuring its overall health. Iansiti et al. (2004) see the responsibilities of the keystone actor to be creating and sharing value with the ecosystem participants (Williamson et al., 2012). By promoting and enhancing the development of the ecosystem, the keystone actor can shape its structure and functioning. Knowledge sharing activities performed by the keystone actor, depend on the nature of the value creation network. Closed or densely embedded networks, engage in intensive exchanges of resources, in the form of knowledge, for example. Whereas more open networks are less easily influenced (Ahuja, 2000) and the keystone, in this case, has less significance. Furr et al. (2018) identify subtle differences in the role of the keystone firm, depending on the nature of the ecosystem – whether centralized or adaptive. In a centralized ecosystem, the keystone actor (addressed as the broker) "connects to partners but keeps them separate, forcing them to work through itself (Furr et al., 2018, p.61)." In an adaptive ecosystem, the keystone (addressed as orchestrator) "connects multiple partners and encourages them to work directly with one another (Furr et al., 2018, p.61)." An overview of literature depicting the 'central actor' in an ecosystem is provided in Table 5.

**Table 5.** Overview of various concepts for the 'central' actor(s) in an ecosystem (Source: author)

| Source | Name of the central actor | Type of ecosystem* | Key activities of the central actor in the ecosystem |
|---|---|---|---|
| Moore (1993) | Ecosystem leader | Business ecosystem | "Leadership enables all ecosystem members to invest toward a shared future in which they anticipate profiting together." (p. 2)<br>• Guide the ecosystem's investment directions and technical standards.<br>• Make sure the ecosystem has a robust community of suppliers.<br>• Maintain bargaining power by controlling key elements of value. |
| Iansiti and Levien (2004) | Keystone | Business ecosystem | "Keystone organizations play a crucial role in business ecosystems. Fundamentally, they aim to improve the overall health of their ecosystems by providing a stable and predictable set of common assets." (p. 11)<br><br>"Keystones can increase ecosystem productivity by simplifying the complex task of connecting network participants to one another or by making the creation of new products by third parties more efficient" (p. 12) |
| Basole (2009) | Keystone | Business Ecosystem | "Keystone players are active leaders in the ecosystem and tend to actively improve the overall health of the ecosystem. They maintain a low physical presence and are generally more effective at both creating and sharing value across the system through platforms. Keystones tend to assume roles of hubs in the network; they are the 'most richly connected' and often lie at the network's core." (p. 147) |
| Zahra and Nambisan (2012) | Ecosystem leader | Innovation ecosystem | "The primary challenge for the established company–typically, the keystone player–is to maintain the relevance of its innovation architecture/platform. In dynamic markets, the relevance of the value created by an ecosystem might diminish over time. This challenges the keystone players to question each and every business assumption that underlies their innovation architecture." (p. 225) |

**Table 5. (cont.).**

| Source | Name of the central actor | Type of ecosystem* | Key activities of the central actor in the ecosystem |
|---|---|---|---|
| Williamson and De Meyer (2012) | Lead firm | Business ecosystem | "Some ecosystems evolve through serendipity and self-organization. However, a "lead firm" can catalyze the emergence and subsequent development of an ecosystem. This lead firm is defined by how it uses smart power[2] to play an active role in stimulating and shaping the business ecosystem around it, rather than because it is the largest or most resource-rich participant." (p. 25) |
| Gawer and Cusumano (2014) | Platform leader | Innovation ecosystem | "Platform leaders need to make business decisions and technology or design decisions in a coherent manner. For example, consider a firm that designs open interfaces to its platform: this will stimulate innovation on complements, and the firms that will act as complementors by designing these complements need therefore to be treated by the focal firms as allies, not potential competitors." (p. 421)<br><br>"In our view, therefore, platform leaders are organizations that successfully establish their product, service, or technology as an industry platform and rise to a position where they can influence the trajectory of the overall technological and business system of which the platform is a core element. When done properly, these firms can also derive an architectural advantage from their relatively central positions." (p. 423) |
| Adner (2017) | Ecosystem leader | – | "The ecosystem leader is the firm to whose vision of structure and roles others defer. It sets, and often enforces, the governance rules, determines timing, and often reaps the lion's share of gains after the ecosystem is aligned." (p. 48) |
| Wulf and Butel (2017) | Keystone | Business ecosystem | "In order to maintain their connections and be able to distribute value, Keystone often introduce a platform of interaction for all partners of the business ecosystem. The distribution of value is not an altruistic strategy but is done for the purpose of growing the own business together with the business ecosystems being the firms most important environment." (p. 174) |
| Dedehayir et al. (2018) | Ecosystem leader | Innovation ecosystem | "An actor assuming the role of ecosystem leader during genesis will firstly engage in governance related actions. These include designing the role of other actors and coordinating the interactions between them. Although these activities are needed throughout the phase of ecosystem birth, we believe that they are especially important in the very early stages of ecosystem creation when actors begin to coalesce but lack structure in their interconnections" (p. 22) |
| Furr and Shipilov (2018) | Orchestrator | – | "However, in many settings today, the requirements are fluid and the objectives less defined. What's needed, therefore, isn't a broker or intermediary to link the various partners but an orchestrator who can find connections among different partners and encourage them to work directly with one another to identify new or nascent opportunities" (p. 59) |

*Scholarly works that do not identify a specific type of ecosystem but discusses ecosystem in a generic manner are marked with " – ".

Altman et al. (2021) suggest that there are distinct capabilities associated with community or network governance aimed at value creation and capture. To orchestrate the ecosystem, may require a specific set of capabilities. Some of the capabilities associated with governing network-based communities include guiding the direction of activities without contractual agreements (Rohrbeck et al., 2009), coordinating the actors and their activities (Gawer, 2014), attracting complementors by offering promotions and incentives (Rietveld et al., 2019).

These capabilities can vary, depending on the type of firm, its industry, its resource base, etc. For instance, incumbent firms have distinct sets of capabilities compared to new entrants or start-ups (Klepper, 2002). On the question of incumbents transitioning their governance structures, Altman et al. (2021) find that most scholars study firms founded within network-based value creation. This underscores that extant research does not consider the transition from product to platform and the subsequent emergence of an ecosystem; rather it focuses on networks (and firms) founded within ecosystems with a particular governance structure (i.e., open-source communities, start-ups developing new technologies). Thus, the literature largely ignores the transition of incumbents to new modes of value creation, such as within an ecosystem (see Altman et al., 2021). Further, ecosystem scholars do not explain how incumbent firms develop the capabilities required to orchestrate an ecosystem and gain access to resources and competences outside their own industry or value chain. Also, ecosystem literature falls short of explaining the conditions (such as new technologies, changes in regulations and shifting customer behaviours) that prevail during the early phases of innovation ecosystems.

## 2.6. A note on related terms

### *2.6.1. The notion of platforms*

The word 'platform' conjures distinct images and meanings. The term 'platform' can refer to "a raised level surface on which people or things can stand, usually a discrete structure intended for a particularly activity or operation" (Baldwin and Woodard, 2009) or to describe products or services that facilitate transactions among independent actors. The product development literature uses the term platform to describe projects involving a family of firm products. In the New Product Development (NPD) literature, it describes projects involving a family of products for a firm with reusable components and technologies (Gawer and Cusumano, 2014). In light of this, Baldwin and Woodard (2009) suggest that product development scholars and industrial economists have developed an overlapping conceptual understanding of the notion of platform.

Since 2000, industrial economists have adopted the term platform to describe products and services that mediate transactions among actors (Rochet & Tirole, 2003). It is used, also, to refer to gaming consoles, software programs, websites, vehicle drivetrains and shopping malls (Baldwin and Woodard, 2009). However, scholarly discourse centres, primarily, on innovation platforms or transaction platforms (Shi et al., 2021). Innovation platforms include technology platforms (Gawer et al., 2002), industry platforms (Gawer and Cusumano, 2014) and software-based platforms (Tiwana, 2015; Tiwana et al., 2010). Transaction platforms are used to explore marketplaces and to facilitate transactions between two parties within a sharing economy via peer-to-peer communication.

Technological platforms have become widespread, due, largely, due to advances in digital technology, which are allowing firms to operate within large networks rather than industry silos or regional supply chains. These platforms provide the foundations which firms can use to develop complementary products, technologies, and services. The platform phenomenon and its usefulness for promoting innovation, are investigated by industrial economists, at multiple levels of analysis: within firm, across supply-chain and within ecosystem (Gawer, 2014, p.1244). The stable, modular platform architecture facilitates innovation and development of complex innovation ecosystems (Gawer, 2014; Lange et al., 2013; Tiwana, 2015). An overview of various types of platforms as presented in management literature is provided in Table 6.

**Table 6**. Overview of different type of platforms in management literature (Source: author)

| **Type of platform** | **The process of value creation** | **Example** | **Article(s)** |
|---|---|---|---|
| Transaction platform | The central actor links the user and the producer. The platform owner relies of network effects | Marketplaces such as e-bay or Etsy; Sharing economy services like Uber and Airbnb | Shi et al. (2021); Tiwana (2015) |
| Software platforms | Value cocreation facilitate by reduced transaction costs and enhancing inter-operability | Windows operating system | Tiwana et al. (2010); Ceccagnoli et al. (2012) |
| Technology platforms | Create value by coordinating actors who can innovate around a modular technological architecture | A telephone network (e.g., 4G network technology) | Gawer (2014); Yoo et al. (2012) |
| Industry platform | The platform supports external innovators and firms to develop their own complementary products or services | Microprocessors and personal computers | Gawer and Cusumano (2014) |

Rietveld et al. (2019) argue that the types of complements required by early platform adopters are different from those required by later adopters. Studies of network effects consider the platform's installed base to be a strong incentive for complementors joining a platform (McIntyre and Srinivasan, 2017). This suggests that 'winner-takes it all' in a platform-mediated network and ignores the strategic management of complements by the keystone firm. According to this view, the platform with the largest number of users will triumph over other competitive platforms and it suggests that complements are developed for platforms that provide access to large number of users.

### 2.6.2. *Modularity*

Prior research describes modularity as a design choice for firms seeking to outsource and standardize their products and achieve scale economics (Baldwin; Henderson and Clark, 1990). Several scholars discuss use of modular architecture in traditional industries (Baldwin,1997; (Argyres and Bigelow, 2010; Jacobides et al., 2016). Modularity enables the building of complex products and systems, based on independent sub-systems (see Baldwin, 1997). It allows a CoPS to be broken down into separate modules to enable recombination and substitution, resulting in economies of scale and scope (Sanchez and Mahoney, 1996). The product modularity literature discusses how firms develop product variants based on standardized interfaces which allow recombinations of modules. This approach to modularity is useful to integrate different components in the basic product and to create new variants in the same product line (Magnusson and Pasche, 2014; Persson and Åhlström, 2013).

For instance, Jacobides et al. (2016) investigate modularity and outsourcing in the automotive industry and highlight the persistence of hierarchically managed value chains despite pioneering efforts related to modularization and outsourcing. The hierarchical industry structure, and modules with closed standards (on OEM's proprietary platforms), ensured that modularization and outsourcing did not lead to the loss of competitive advantage by the OEM. Also, the OEM's control of the product platforms meant that outsourcing did not result in modular open-access segments, as was the case in the personal computer (PC) industry. In fact, the OEMs strengthened their positions by exploiting modularity to expedite asset shedding and capital intensive operations (Argyres and Bigelow, 2010). Since the 1990s, OEMs have become adept at developing car platforms with a modular architecture, which facilitates outsourcing (see Jacobides et al., 2016). Further, modular architecture as espoused in physical products are somewhat non-permeable. That is, the modules possess a fixed boundary and have limited potential to offer new value beyond the design architecture of the original product. (Autio et al., 2016; Baldwin 1997; Baldwin and Woodard, 2009). The layered architecture of a digital product does not have fixed boundaries and thus offer unlimited potential to offer new value beyond the design architecture of the original product (Yoo et al., 2010). In the PC industry, modular segments with standardized interfaces help intertwine multiple innovation trajectories from diverse industries, from microprocessors to cloud computing. This approach helped the end-user integrate hardware and software independent of the OEMs in the PC industry.

Thus, manufacturing firms need to establish permeable interfaces that allowing interoperability between hardware and software (see Yoo et al., 2010). Since the 1960s, interface has been understood as referring to the interconnections among various elements in a computing system (Reid and De Brentani, 2004). In platforms where a physical product base hosts an IoT technology layer and digital layer, layered modularity allows separation of the activities related to hardware and software (Hodapp et al., 2019; Yoo et al., 2010). The use of interfaces (such as APIs or open-source protocols) allow interaction among the different platform layers (see Figures 1 and 2). Application Programming Interfaces (APIs) and Software Development Kits (SDKs) in the software layer, help third-party developers to contribute to the focal firm's value proposition (see figure 3 and 4).

As physical products transition into platforms, it is making value creation more difficult, as manufacturing firms now need to include Internet of Things (IoT) technologies to physical products (Roecker et al., 2017). Developing physical products (such as smartphones, e-books readers and computers), which contain with digitized components, involves concurrent value creation activities, engaged in by several actors to co-create value (Yang et al., 2018). In this setting, value creation activities are non-linear and result in development of complementary products and services. The firms involved in developing digitized products and services, participate in broad networks, which allow them to integrate distinct systems and technologies to produce a focal value proposition (Dattée et al., 2018). Increased digitization of products and services calls for manufacturing firms to create an ecosystem that allows third-party actors to contribute to the main value proposition and develop complementarities.

### *2.6.3. Digital technology and generativity*

In contrast to physical products, digitized products[3] (such as smartphones) are characterized by generativity and continuous creation of value based on the ability to allow users to access and consume other digital products and services (Autio et al., 2016). Compared to a product-specific modular architecture, a digitized product has a layered architecture that provides an interface between the physical product and technology or software layer (Autio et al., 2016; Yoo et al., 2010).

The generativity of digital technologies means that value is continuously created through unexpected combinations and unpredictable innovations. Thus, "the value of a product or service transcends its own boundary and, spills into new, and often contested, domains" (Cennamo 2021, p. 268). Information systems scholars consider that the layered modular architecture of digital infrastructures supports generativity (Yoo et al., 2010). Traditionally, Information Systems (IS) research study the impact of IT on services and systems, however, in recent times, IS researchers have started to explore the the impact of digital technologies on physical products.

As digital technologies become widespread, they are influencing the process of value creation in traditional industries such as automotive, aviation and financial services. The implementation of digital technology is breaking down industry boundaries and increasingly making innovation a complex inter- and intra-industry endeavour (Yang et al., 2018). This implies that value creation is no longer a firm or industry-specific activity. Thomas and Autio (2019) employ the term, generativity, to describe the capacity to generate unpredictable innovations from a set of uncoordinated actors. This highlights the ubiquity of generativity for each participant and distinguishes the concept of ecosystem from other concepts in the fields of innovation and organizational studies. In essence, generativity emphasizes the ubiquity of ICTs to link diverse sets of actors and facilitate a steady stream of innovation which would be impossible for a single actor.

[3] Digitized products are physical products with digital technologies such as Internet of Things (IoT) technologies or Augmented Reality (AR).

Cennamo (2021) emphasizes that digital technologies can be distinguished by their generative characteristics. That is, the functionalities and features of digital technology based products can improve continuously or evolve after commercialization (Yoo et al., 2010). However, industrial age products (e.g., bicycles, trains, television) are designed for specific uses and their value (perceived by the customer) may differ with the quality or reputation of the product (Cennamo, 2021). However, digital products consist of interconnected goods or services, produced by participants in multiple industries to co-create value. Several scholars use the smartphone example to highlight the unbounded nature of value creation (Cennamo 2021; Yoo et al., 2010; Yoo et al., 2012).

# 3. Method

*This chapter describes the methodological choices that have been used to address the research questions. After discussing the research design, the chapter provides an overview of the data collected in the longitudinal case study. Following this, the analysis of data is explained and finally, reflections on the research quality is presented.*

### 3.1. Background

This doctoral research project on Volvo's AD technology development began with an investigation of a 'complex innovation project' in an incumbent automotive firm. In 2016, I was given access to the then Volvo Drive Me project. The first step in the field work was a pilot study to try to immerse myself in Volvo's AD project and familiarize myself with Volvo's internal operations and managerial practices. The early field work showed that autonomous (or driverless) cars were a departure from previous automotive industry innovation projects, as described in literature. The pilot study provided an understanding of AD technology development and the collaboration between Volvo and technology firms.

The NPD and Complex Product Systems (CoPS) literature was useful for early analysis. However, as I gained more insights on the technology per se and the Volvo case, I found that the related activities were taking place in a cross-industry collaborative network among several actors. The dependencies between Volvo and non-automotive firms – such as software and semiconductor firms – were intense and the network was much broader than in previous automotive industry innovation projects. Over time, as I developed a contextual understanding of the phenomenon, it became clear that in order to successfully bring this technology to the market, Volvo had to actively engaged with the regulator, technology firms, start-ups, research institutes and universities. Most of these interactions were not governed by contracts or licensing agreements.

Adner's (2006) work on innovation ecosystems and the case of the Michelin run-flat tyre, demonstrated the utility of the ecosystem concept to investigate the development of the AD technology. The idea of an ecosystem is centred around the focal offer (phone, computer, television), whereas concepts based on interorganizational centres on the focal firm (see Shiplov & Gawer, 2020). I realized that the evolutionary, non-contractual (in many areas), and interdependent characteristics of the collaborations taking place at Volvo's AD project could be better explored using the concept of innovation ecosystem. Also, the successful commercialization of AD technology involved developing the entire ecosystem for driverless vehicles. Studying such a complex phenomenon, i.e.., the emergence of an ecosystem, in which developments occur over time, necessitated a long-term perspective.

To contribute to theories on organizational adaptation, innovation, and change, it has been argued that it is necessary to "explore the contexts, content and process of change together with interconnections through time" (Van de Ven et al., 1990, p. 215).  Several scholars favour longitudinal studies to understand value creation in an ecosystem, including its emergence, evolution and decline (e.g., Alain et al., 2019; Gawer et al., 2014; Jacobides et al., 2018).

### 3.2. Research design

The research was designed as a longitudinal case study (Perks and Roberts, 2013; Van de Ven and Huber, 1990), which provides opportunities to gather rich empirical data on a phenomenon that is evolving within a real-life context (Eisenhardt & Graebner, 2007; Yin, 2009). It also facilitates a better understanding of the specific context, that is, how the various agents (individuals) and units (teams) interact and why. Langley (1999) emphasizes the importance of rich longitudinal data to study things that evolve over time (Gehman et al., 2017).

Yin (2009) suggests that a case study design is appropriate to study "how" and "why" questions and to investigate events that are difficult to control or manipulate. Although there is a lack of consensus on the definition of case study (Dubois et al., 1999), I use Yin's (1994, p. 18) definition that: "a case study is an empirical inquiry that investigates a contemporary phenomenon in depth and within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident".

Due to the highly contextual nature of my case, I began by conducting a pilot study. It has been argued that a pilot study is an important first step in case study research, although Goffin et al. (2019) show that among the studies they reviewed, around 93% did not include this step. In the context of this thesis research, the pilot study was instrumental in deciding the data collection methods. The aim of the pilot study was to embrace serendipity and intuition. The pilot study showed that the innovation activities in the case firm took place in an inter-organizational network that included actors from several industries and geographies and public agencies. To make sense of the phenomenon, I could not rely on data sources such as industry reports, databases or other records such as patents, capital employed and revenue. I needed to find a credible way to engage directly with senior managers, to understand internal discussions and the relationships among multiple stakeholders. My data collection was facilitated by field visits where I participated in internal meetings as an observer. Field observations, of different teams and units, gave access to the multitude of factors involved in the activities, decisions, and outcomes. This data collection method, in which the researcher is immersed in the case setting as 'participant as observer', is described as an ethnographic method (Aktinson et al., 1998; Anderson, 2009; Yin, 2009).

Studying social construction processes implies that we focus more on the means by which organization members go about constructing and understanding their experience and less on the number or frequency of measurable occurrences. Gioia et al. (2012, p. 16) emphasize this by quoting Einstein, "Not everything that can be counted counts, and not everything that counts can be counted." Ethnography allows for prolonged immersion in a research site, which facilitates sense making and thereby allows the ethnographer to discover new and often unanticipated processes (Cunliffe, 2016). An ethnographic approach to my case study helped employ an open approach to data collection, relying on field notes from participant observation and semi-structured interviews (Alvesson and Kärreman, 2007). Sociologists such as Whyte, Goffman and Beckman argue that "fieldwork, participant observation and native interpretations are crucial to understanding the empirical world." Therefore, a trade off was made between generalizability and comparability for internal validity and causality in specific outcomes (Miles and Huberman, 1994). This also guided my literature review and helped me make sense of how the phenomena in question could be understood.

A complex phenomenon, such as emergence of an ecosystem for value co-creation, requires a long-term perspective and a qualitative method. Studying a single case enabled me to stay within the constructionist epistemology (Easterby-Smith, Thorpe, & Jackson, 2012), and allowed for in-depth investigation of the phenomenon, which was developing in real time, making it difficult to anticipate outcomes ex-ante. The empirical context warranted a qualitative approach (Flick, 2014) as the emphasis was on a "specific case, a focused and bounded phenomenon embedded in its context" (Miles and Huberman, 1994, p. 10). A deductive quantitative approach would not have been appropriate for this unique context.

### 3.3. Abductive reasoning

The focus of the research shifted from studying a firm-specific innovation project to exploring the innovation activities taking place in an inter-organizational network. Thus, the concept of ecosystem fitted the empirical reality, that is, the shifting dynamics of value creation in the automotive industry. However, I was puzzled about how to define, distinguish and deduce the presence of an ecosystem in the real world. Scholars us the concept of ecosystem to explore value co-creation among independent actors without hierarchical control.

In 2018, during my second year of doctoral study, I participated in a special lab session at the EURAM conference titled "Abduction: Implications for Management and Organizational Research". This introduced me to the works of Popper (1995), Bamberger (2018) and Alvesson & Kärreman (2007). Abductive reasoning helped me embrace assumptions and anomalies as strengths rather than weakness and provided explanations that served to tighten the connection between the data and the theory (Behfar & Okhuysen, 2018; Locke et al., 2008). Due to the interpretative nature of my research, I describe it as constructivist inquiry (Lincoln, 1985, 2007). According to Guba et al. (1982, p. 5), "positivist inquiry (quantitative) assumes a single reality and inquiry findings are based on a single reality", whereas a constructivist considers multiple realities as alternative explanations for the social reality. Constructivist inquiry deals with research that is interpretative and non-experimental in nature (i.e., non-positivist). This leads to abductive reasoning, based on sense-making and perceptions of the case (Gioia et al., 2013).

Abductive reasoning allowed me to generate plausible explanations based on the situational reality of my case. Alvesson and Kärreman (2007, p.1265) suggest that empirical material does not lead to theorizing or filtering of ideas. They prefer data or empirical material, which they describe as an "artifact of interpretations and use of specific vocabularies" (p. 1265). I was cognizant of the fact that the vocabularies used by the case firm and my familiarity with the firm and its internal operations (due to my extensive association with them since my master's project), influenced how the data were construed and the reasoning based on them.

### 3.4. Data collection

Data were collected between 2016 and 2021, from different sources using different methods. The qualitative data sources include field observations, expert interviews and secondary sources (see Table 7). This type of data collection, where the researcher is immersed in the case setting, is described as an ethnographic method (Anderson, 2009; Yin, 2009). A total of 56 semi-structured interviews were conducted with experts at Volvo and some of the partner organizations. Several informal discussions also took place during the field visits. The interviewees were selected using the purposive snowballing technique (Miles and Huberman, 1994), that is, initial interviewees were asked to recommend other subject-matter experts; this continued until saturation was reached. For qualitative research, most scholars suggest that between 40-60 interviews lead to saturation (Mason, 2010).

The data collection was conducted in two phases. Phase A focused on Volvo's activities related to the development of the AD technology and began in 2016 with Volvo's Drive Me project. From 2019, Phase B data collection was conducted mainly at Volvo and involved attendance at meetings between Volvo and its alliance partners and interviews with external actors. In 2019, Volvo's AD program included several alliances to co-create the AD technology platform.

**Table 7:** Overview of the longitudinal case study

| | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 |
|---|---|---|---|---|---|---|
| **Activity and events** | AD project at Volvo | Joint venture alliance | New alliances with non-automotive firms | Agile transformation at Volvo | Volvo and Veoneer rescind the joint venture alliance | Interviews and discussions with primary stakeholders |
| **Purpose** | Explore the AD project at Volvo (pilot study) | Study the spin-off of Volvo’ s active safety unit | Study the collaborations in the AD program | Focus on Agile methods and interface with Zenuity | Explore the coordination challenges in the network | Understand new changes in the AD program |
| **Unit of analysis** | Firm level | Firm and platform level | Firm, platform and Network level | Platform and network level | Platform and network level | Firm level |
| **Data collected** | Interviews (2) meetings (11) | Interviews (20) meetings (17) | Interviews (6) meetings (61) | Interviews (16) meetings (25) | Interviews (9) Number of meetings (3) | Interviews (3) |
| **Actors involved** | Volvo | Volvo and Zenuity | Volvo, Zenuity, Drive Sweden, Trafikveket | Volvo, Zenuity, Drive Sweden, MobilityXlabs | Volvo, European OEM | Volvo |

### *3.4.1. Phase A – Volvo's Drive Me project (2016-2019)*

In Phase A, the focus was on exploring Volvo's internal activities and operations related to developing the AD technology. I began my study of what then was called the Drive Me project. Drive Me was an ambitious project to develop fully autonomous cars and involved partnerships between Volvo and several - both public and private - actors. I attended important events, workshops and internal meetings related to the Drive Me project. Initially, I observed business and strategy related meetings, but later included observation of technical meetings. These meetings involved discussions about resources, technical requirements, and strategic actions. Some of the meetings (Business project meetings, Decision Review Meetings (DRM) and Technical Review Meetings (TRM) were observed on a weekly basis). Various senior managers, responsible for alliances and partnerships such as Uber, Baidu, Drive Sweden, and Trafikverket, participated in these meetings. My primary stakeholders at Volvo, identified the most relevant internal meetings and the most appropriate interviewees. During this period, Volvo made significant changes to its Drive Me project.

One of the major decisions made by Volvo was to form a Joint Venture (JV) with Autoliv. The JV resulted in the establishment of a separate company to develop AD and ADAS (Advanced Drive Assistance Software) solutions. Other new alliances were established by Volvo to cope with the complex nature of the AD technology. My initial focus on an internal project within an incumbent firm, expanded to a focus on an inter-organizational innovation project. In 2018, the Drive Me project transitioned to an AD programme, to develop AD technology, which highlighted the long-term nature of the development activities related to autonomous vehicles.

### *3.4.2. Phase B – The AD ecosystem (2019 – 2021)*

In Phase B, the fieldwork was focused on understanding the interactions among the various actors involved in the AD programme. The spinning-off of Volvo's active safety unit, as a stand-alone software firm, indicated that platform development was taking place outside of Volvo. To follow the growing number of alliances and partnerships, I studied the entire network surrounding Volvo's AD technology platform. For instance, I shadowed Volvo's team in workshops hosted by Drive Sweden and observed field tests to demonstrate autonomous car prototypes to transport authorities. Thus, Phase B had a more inter-organizational perspective. During Phase B, I went to Mines ParisTech university in Paris to collaborate with researchers working with Renault since many years. The intention was to conduct a comparative study of emerging automotive ecosystems in France and Sweden during February to April 2020. Due to the Covid-19 pandemic outbreak in March 2020, the study was unfortunately cancelled, and I returned to Sweden after only one month.

My recognition that Volvo's AD technology development was taking place primarily outside Volvo's boundaries, resulted in the need to understand the external alliances and collaborations involved in the AD program. I attended Business Liaison Meetings (BLM) between Volvo and Zenuity (now Zenseact), participated in events hosted at Mobility Xlabs and interviewed individuals working with Volvo's alliance partners. Thus, the data collection in Phase B focused on the overall ecosystem surrounding Volvo's AD platform.

### 3.5. Data analysis

The exploratory and longitudinal approach adopted resulted in an iterative research process of parallel data collection and analysis. One of the problems encountered was the huge amounts of data collected. Over time, the sheer volume of the data required a structured data analysis process. Gioia et al. (2013) acknowledge that it is  not unusual to feel "lost" in the data analysis process. However, the rich data gathered required a structured analysis in order to provide value. Thus, I decided to conduct the data analysis concurrently with the data collection (Dubois et al., 2002; Maxwell, 2012). The first part of the data analysis involved mapping the data using Xmind software. The focus at this stage was on identifying important activities, events and changes to the project. The second part involved data analysis using Nvivo software to allow data clustering based on codes. To categorize and identify patterns in the data, I used NVivo codes (Easterby-Smith et al., 2012). The data were coded according to non-hierarchical user-defined nodes and the coding process was guided by literature.

A qualitative study design involves the extent to which the researcher should decide on the methods in advance (see Maxwell 2005, p. 80). Inflexible structuring of the study and study methods risks rigidity and inability to incorporate emerging insights. Maxwell (2005) states that pre-structuring the method can create methodological tunnel vision when trying to make sense of the case. To avoid this, I formulated a tentative plan which allowed for revisions and incorporation of emerging insights. This type of approach is useful when studying a particular phenomenon where internal validity and contextual understanding are important for revealing the "processes that led to specific outcomes" (see Maxwell 2005, p. 80).

#### *3.5.1. Systematic combining*

Due to the emergent and unique nature of the phenomenon, the research tended to be iterative (Dubois and Gadde, 2002; Siggelkow, 2007), involving recurrent revisiting of the empirical data and the theory to better understand the context. By moving back and forth between the empirical setting and the theory, the research design is in line with a systematic combining approach (Dubois et al., 2002). This allowed new questions to emerge during the longitudinal study.

Using the systematic combining approach (Dubois and Gadde, 2002), codes were developed based on the emerging data and the NPD, innovation, value networks and innovation ecosystems literatures. The process of revisiting the literature, in light of the emerging insights, and adding new codes to the Nvivo mapping, led to a process of sense-making of the data. The overall process of analysis is depicted in Figure 1.

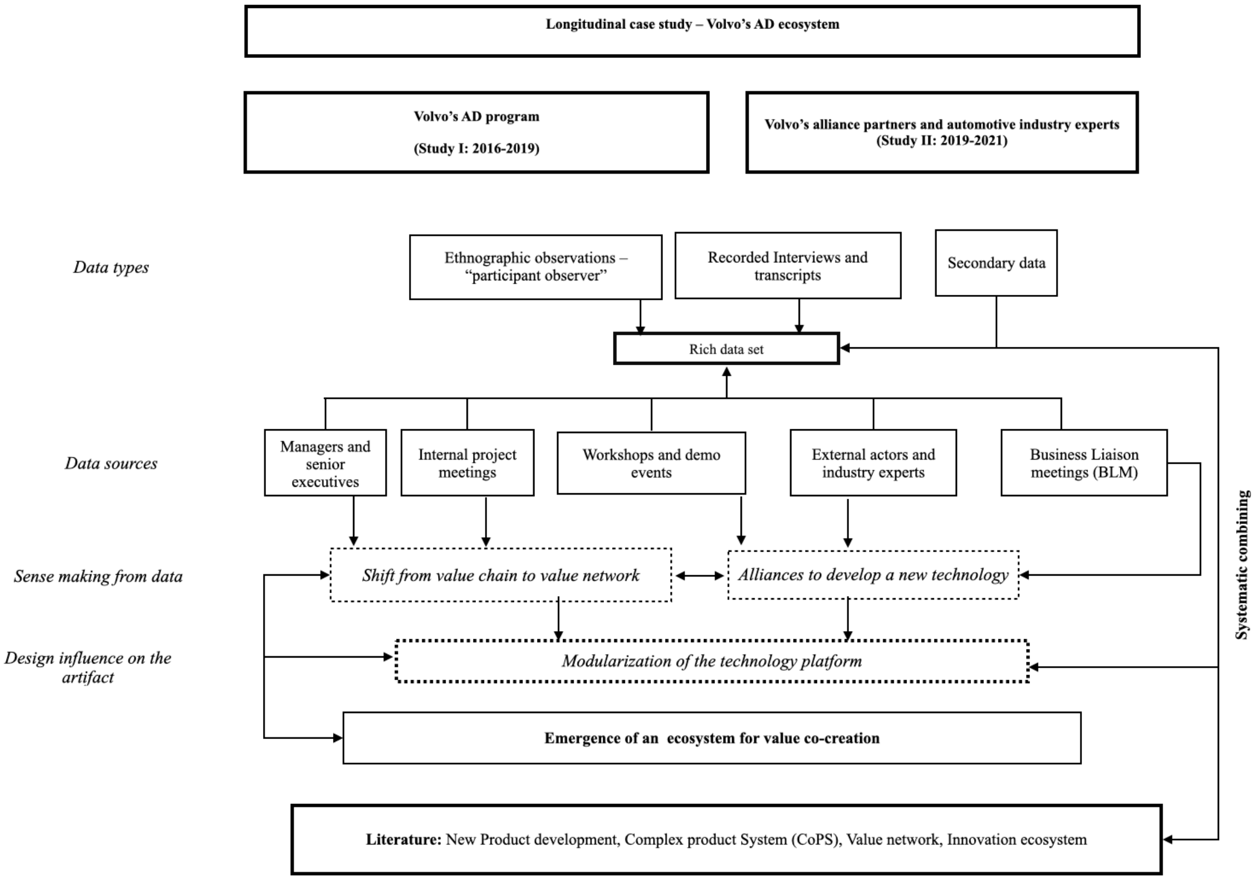


**Figure 1.** An overview of the data analysis process and the systematic combining approach (Source: author)

### 3.6. Reflections on methodological choices

This thesis has several limitations as the research had an exploratory approach, that is, the focus is on expanding existing theory and not to test theory. It is based on an in-depth longitudinal case study of an incumbent manufacturing firm. Thus, the findings should be considered applicable to similar industrial setting characterized by technological change and digitalization. In particular, the thesis mainly addresses how incumbents leverage the resources and competences of external actors to co-create a new technology platform in an ecosystem.

According to Guba and Lincoln (1994), trustworthiness and authenticity is an appropriate way to evaluate qualitative studies. Trustworthiness can be related to transferability, i.e., the ability to transfer the findings from one study to another. It allows researchers to transfer the findings to recombine and create new knowledge. In my research, I studied an incumbent firm's alliances and activities related to the development of new technology. To increase the transferability of the results, I provide detailed accounts on the case study in the thesis, including the appended papers. By collecting data ethnographically, I used direct insights from internal meetings, workshops and other day-to-day activities taking place at the firm for over a period of four years. Throughout the four years, I carried out regular interviews at Volvo and some of its partner firm in the AD program. Further, I interviewed some automotive industry experts in France to get insights into the macro-level transformation transpiring in the automotive industry.

Authenticity relates to providing meaningful and valuable insights that can contribute towards theorizing. It relates to the research fairness in interpreting data and balance divergent perspectives. In order to substantiate my interpretation of the data, I had regular interactions with my industry stakeholders. This ensured that the interpretations and insights were consistent with reality. One of the appended papers was co-written with a senior manager at Volvo. Regular presentations were made at the case firm to discuss emerging findings and key areas related to the studied phenomenon. Also, both interviews and observational data were analysed using software to overcome human errors. Further, the interpretation of the data and developing the findings was done collaboratively with my co-authors. Also, feedback was received from researchers and professors at both Chalmers University of Technology and Mines ParisTech in Paris where I spend several weeks as a visiting researcher. Apart from this, working papers and research proposals were presented at internal seminars at the department. Thus, several measures were taken to ensure authenticity.

In qualitative studies, generalizability is low (Eisenhardt, 1989) and thus invites the discussion on generalizability. However, case study research is more about in-depth examination of one or a small number of events or firms (Easterby-Smith et al., 2012). Therefore, in qualitative case studies, it is important to identify suitable case(s) that are representative of the phenomenon under investigation. To increase generalizability, I conducted a pilot study to understand the case context and activities and thereby choose relevant literature to develop insights on organizational and network context. The decision to conduct the research as an exploratory study was an attempt to improve generalizability. Further, to ensure valid and reliable results, as a researcher with constructivist epistemology, I triangulated data from multiple sources (Golafshani, 2003). Use of data from field observations, interviews, and archival sources, allowed an understanding of the case context, the technological factors involved and the perspectives of personnel in the case firm.

The longitudinal case study design therefore warrants some discussion of research quality and limitations. First, the single-industry focus raises problems related to external validity and generalizability of the findings. Second, issues, such as geo-politics, country-specific traffic, and safety regulation, etc., are not captured in the study. Therefore, it is important to discuss how the findings from this research might vary in the case of other industries, geographies, and technologies. Third, the use of qualitative data leaves room for subjective interpretations by the researcher, and a major role of contextual factors and interview settings.

# 4. Empirical context

*In this chapter, the empirical context of the automotive industry and the developments related to autonomous vehicles are described.*

### 4.1. The automotive industry

The automotive industry is a driver of economic progress and, since vehicles are composed of many components and materials, the development of this industry echoes other advances in the modern world. The vehicle has extended human mobility for generations and vehicles are subordinate to the demands of humans (Lee et al., 2016). The industry has adopted all major technologies, ranging from mining to semiconductors. For many years, the automotive industry was dominated by a few Original Equipment Manufacturers (OEMs). Traditionally, its R&D efforts were in the areas of material science, mechanics, electronics, and industrial engineering and were aimed at promoting and increasing the performance of the IC engine (Mondragon et al., 2007). The dominance of the IC technology led to other forms of propulsions and alternate fuel sources not being considered. However, the rapid advances in communication, sensor systems and the cloud infrastructure are causing increased complexities, which are beyond the competences and resources of OEM value chain (Lee et al., 2016). Consequently, OEMs are now being challenged by new entrants and diversifying firms from other industries with significant resources and competences in artificial intelligence, cloud computing, etc.

Since the invention of gas-powered cars in the late 19$^{th}$ century, automotive technologies have increased hugely. The mass production of cars paved the way to innovations such as turn signals, windshields, and air conditioners. Even small and modestly priced cars now have radios, CD players, GPS, memory drives, GPU (graphics processing unit) and advanced safety systems. In contrast to earlier automotive technologies, modern vehicles are digital platforms enabling smart mobility. The technology in a smart vehicle consists of smart sensors, radar, camera, lidar, vehicle to vehicle communication, electric drive and artificial intelligence programming to manage the driving functions. Thus, OEMs need to interact more widely than within their traditional industry value chain.

The hierarchical approach of the OEMs as a strategy to cement their position as system integrators and thereby control value creation and capture is being challenged by the entry of new actors in the industry. Jacobides et al. (2016) studied the "industry architecture" of the automotive industry and structural changes in value chain of the industry. They explored the OEMs' role in transforming the entire industry and identified that OEMs, in the late 1990s and early 2000s have focused on transforming the industry from a vertically integrated to a more vertically unbundled and modular structure. This shift towards 'vertical unbundling' was largely motivated by transformations in the computer industry. However, Jacobides et al. (2016) claim that the OEMs were only partly successful and failed to deliver the expected benefits of outsourcing and modularization. They highlight the missteps of the OEMs and argue that the strive to develop modular, open-access archetypes did not result in vertical unbundling that transpired in the computer industry. What began as an effort (by the OEMs) to pivot towards modularity, in mid-2000s, only resulted in more outsourcing and did not achieve the full benefits of modularity (Jacobides et al., 2016). Modularity and outsourcing have been a common structure of the automotive value stream, with the OEMs maintaining hierarchical control through patents. The modular product architecture helped the OEMs scale and reach volumes to decrease cost.

The automotive industry is witnessing a shift in innovation practices due to discontinuity from both the technology and market perspective (Ili et al., 2010). Along with changing technology and market trends, the value stream dynamics is also shifting from a hierarchical structure towards a network mode of operations. Although the role of OEMs in the development of new technologies (such as autonomous drive) is becoming less prominent, it is still unclear who will control the value creation and capture in the future. The innovative landscape of the industry has alerted significantly as IC engines are replaced by other forms of transmission and the industry is moving away from a value chain model to that of a value network.

### 4.2. Autonomous Drive (AD), a discontinuous technological change

Today, vehicles are transitioning into platforms, capable of autonomous navigation and decision making (see Figure 2). AD is a technology that enables drivers to delegate driving functions to the vehicle and allows it to make decisions using inputs from sensors, clouds, and machine learning algorithms (see Figure 3). The complexity involved in developing new technologies is pushing the original equipment manufacturers (OEMs) to collaborate with non-automotive technology firms in order to access complementary assets, technological expertise or specialized knowledge. Motivated by the developments in the computer and phone industry, firms from the technology industry and start-ups are pioneering a platform strategy around autonomous driving and electrification.

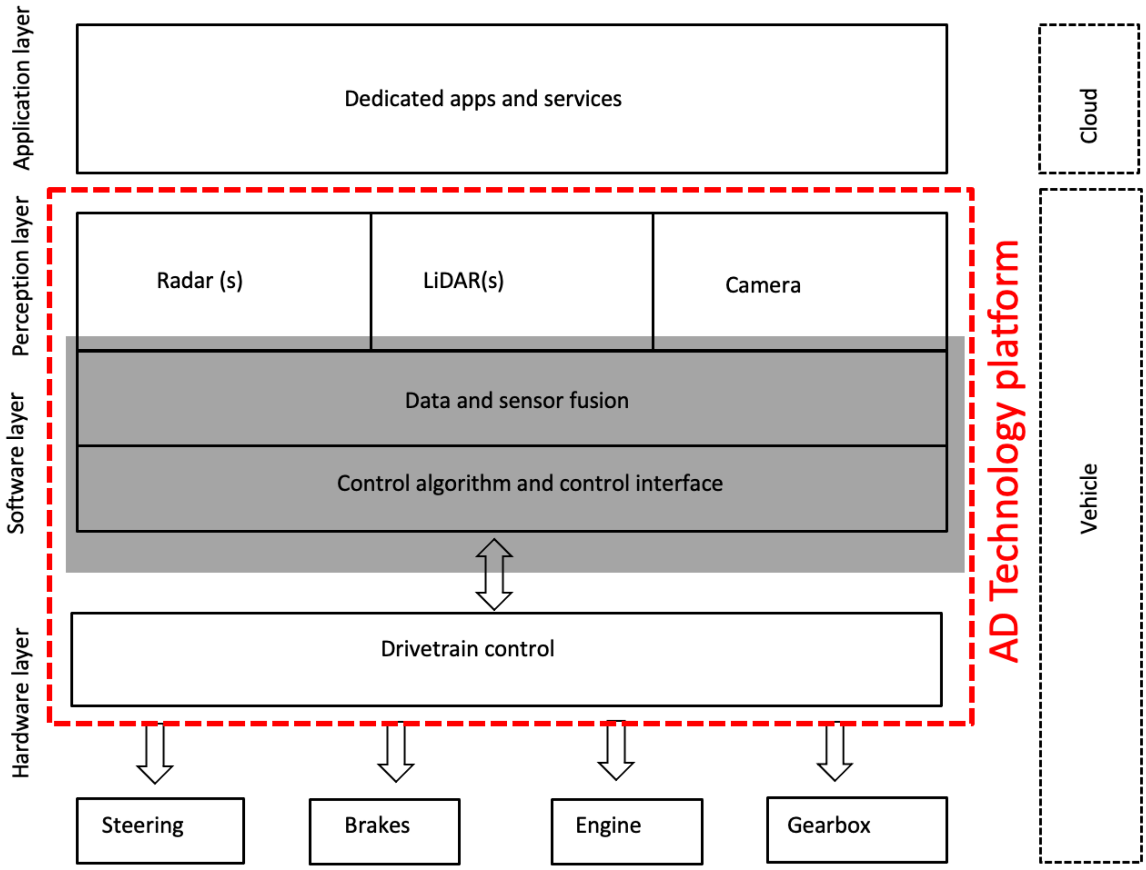


**Figure 2**. Main technological systems in autonomous vehicles (Source: author)

For several decades, the automotive industry value chain has been orchestrated by the strong OEMs. However, in recent times, the dominance of the OEMs is being challenged by the entry of new and diversifying firms (Donada, 2018; Nikitas et al., 2019). The hierarchical control exerted by the OEMs over its tier 1 and tier 2 suppliers (Jacobides et al., 2016) is no longer advantageous.

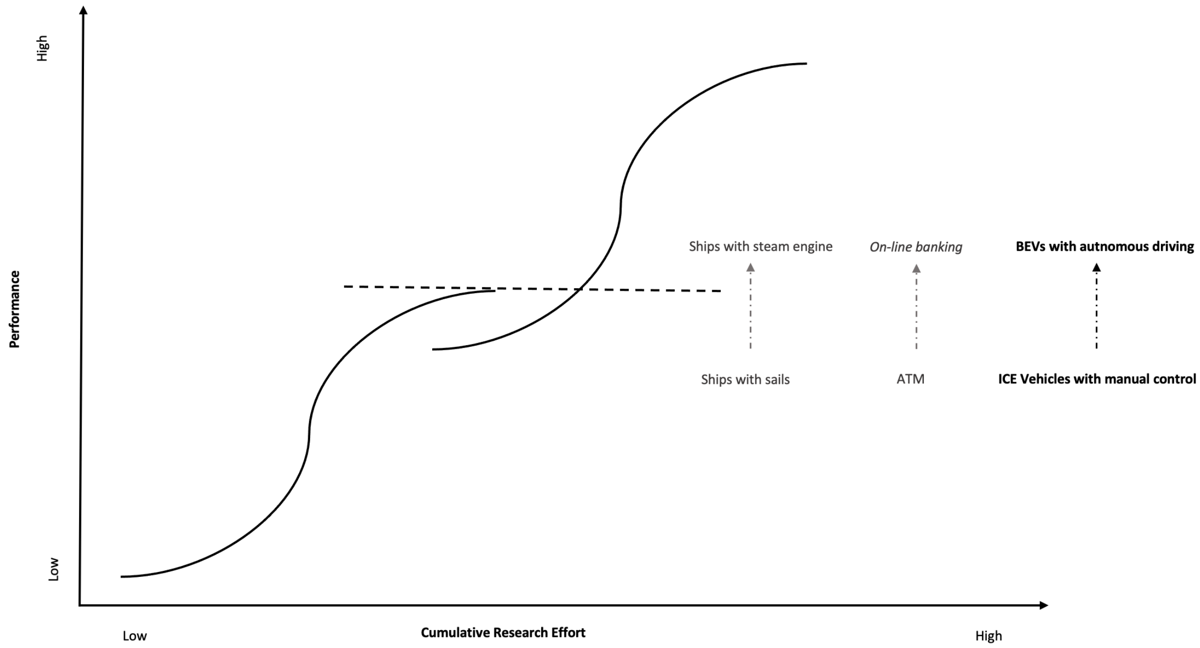


**Figure 3.** Mapping autonomous driving as a discontinuous technological change in the automotive industry (Source: adapted from Lambe et al., 1997)

## 4.3. From product to platform: Vehicles as digital platforms

The proliferation of digital functions and features in industrial products, such as cars, phones, and televisions, has had a profound impact on the industry structure and competitive landscape (Yoo et al., 2010). The automotive industry is witnessing rapid changes in term of both technology and market trends. The technology and product life cycles are becoming shorter due to rapid advancements in digital technology. In order to grapple with this seismic shift and sustain the competitive advantage, automotive firms need to develop new strategies. The magnitude of digital interfaces in modern cars are increasing exponentially (Pretschner et al., 2007). In 2010, it was estimated that a top segment vehicle encompassed one gigabyte of software, and this has been increasing ever since. Also, in mature markets, customers are expecting more value for the same price, which translates into demand for new digital features and functions. Further, the lower cost of communication hardware has become an enabler of advanced electronic systems, which, in cars, increase safety, fuel efficiency and comfort (Pretschner et al., 2007).

New technological changes require industry consensus, with majority of the players converging on a common technology (Murmann & Frenken, 2006). An example here is the Intel's evolution from a microprocessor supplier to a major player in Personal Computer (PC) industry. Intel's role in the evolution of PC architecture and its subsequent platform leadership is well documented. Despite its current dominance in the PC industry, Intel faced several challenges in the early 1990s, related to growing its microprocessor business. To overcome the challenges, both in terms of technology and business opportunities, Intel pursued a platform strategy (Cusumano and Gawer, 2002), with a hardware layer and a software layer. Intel's success depended not just on the technological superiority of its platform, but also on the development of an operating system, software development tools, hardware (monitor, keyboard, storage devices) etc. (Cusumano and Gawer, 2002).

In an era where digital technology and platform innovation are ubiquitous (see Wei et al., 2019), the ability of OEMs to orchestrate collaborations in wider networks, beyond just the automotive industry is important. The Microsoft-Intel partnership in the PC industry, illustrates the importance of ecosystems for bringing new technologies to market. Single firms can find it difficult to establish a standard for a new technology. Also, customers for new technologies, often look for complementary assets and innovations that will increase their value.

# 5. Summary of appended papers

*In this chapter, the main findings from the four appended papers are summarised. The full versions are appended at the end of the thesis.*

## 5.1. Paper I: Tactical capabilities in agile NPD projects: Insights from an autonomous car project in Sweden

This paper is based on data from a longitudinal case study of Volvo Car Group's autonomous car project. The case firm's transformation from a waterfall- based to an agile development method, enabled an understanding of how tactical activities differ between the two methods. This paper argues that agile development methods are better facilitators of use of tactics in NPD projects.

In the contemporary fast-paced, digital economy, organizational abilities to manage uncertainty are becoming a priority for both large and small firms. Paper I discusses how an agile methodology can support an R&D project handle emergent challenges. One of Volvo's senior managers frequently used the words tactics and tactical activities. He believed that the uncertainty and complexity related to developing AD technology required a tactical mindset. Further discussion with him about the importance he assigned to tactics, revealed that the plan-driven methodology, used at the firm, curtailed flexibility, and adaptability. He believed that a change from a plan-driven (waterfall) to change-driven (agile) methodology, would be more tactical. This provoked an interest in understanding the duality between agility and tactics. This paper explores how the transformation to an agile method influenced tactical activities in an NPD project.

Prior research on project management and NPD identifies both strategy and tactics as important for success. However, an agile rather than plan driven waterfall development is considered the better alternative. Interestingly, both tactical activities and agile methodology deal with adaptation to emergent challenges and managing uncertainty in projects. However, few scholars explore the use of an agile development methodology to support tactical activities in NPD projects.

This paper is based on data from a longitudinal case study of Volvo Car Group's autonomous car project. The case firm's transformation from a waterfall- based to an agile development method, enabled an understanding of how tactical activities differ between the two methods. Based on observations, this paper argues that agile development methods facilitate the use of tactics in NPD projects.

### 5.2. Paper II: Joining forces to create value: The emergence of an innovation ecosystem

Paper II aims at providing a better understanding of the process of ecosystem emergence during a period of DTC. The alliances literature does not fully explain the changing dynamics in the value creating activities in the digital economy. The innovation ecosystem concept is used by scholars to investigate activities related to joint value creation or co-creation of value, involving a network of actors. The interactions within an innovation ecosystem are typically organized around a technology platform, consisting of shared assets, standards and interfaces. Modularity and non-generic complementarities are considered important underpinnings of this ecosystem. However, few empirical studies explain how the firm uses this modular platform to develop non-generic complementarities.

At a theoretical level, Paper II describes the process of ecosystem emergence, by tracing the alliances set up by an established firm, to develop a new technology platform. Based on a longitudinal case study, Paper II highlights how the alliances established by Volvo during a period of DTC, influenced the platform architecture and triggered the emergence of an ecosystem. The findings show how the various alliances initiated by an established firm co-created a complex value proposition. In particular, the JV had a major influence on the platform modularization. The paper highlights how the seeming disadvantage of not possessing the resources and competences required to develop the new technology, triggered the search for alliances and led to modularization of the platform.

Paper II describes the transformation of an internal (firm specific) platform into a modular platform (during a period of DTC), and its influence on the development of non-generic complementarities. It highlights a subtle, but important distinction between modularization for outsourcing and modularization for value co-creation (during a period of DTC). The modularity discussed in this paper differs from the type of modularity described by scholars studying automotive value chains. The accidental modularization of Volvo’s AD platform was unique based on the different ‘layers’ in this technology platform.

By introducing the notion of ‘layered modularity’, the paper informs practitioners about the importance of developing platforms able to serve its own installed based in one layer and complement another firm’s installed base in another layer. It argues that layered modularity that facilitated the development of non-generic complementarities and lead to the emergence of an innovation ecosystem.

### 5.3. Paper III: Keystone orchestration in an emerging ecosystem: The case of autonomous drive technology development in Sweden

Like Paper II, Paper III focuses on ecosystem emergence. It uses the case of Volvo to investigate how a keystone firm coordinates activities among a network of actors. Paper II discusses the emergence of an innovation ecosystem around Volvo's technology platform; Paper III focuses on Volvo's role as a keystone actor. In this paper, the various activities related to aligning activities both at the firm and network level is discussed. Although ecosystems consist of independent actors, there is need to coordinate development actors amongst the actors.

The ecosystem literature describes a keystone actor as being responsible for coordinating activities among the different actors in a network. This can be difficult during the emergence phase of an ecosystem where roles and rules of engagement have yet to be determined. There is a lack of knowledge about ecosystem governance and, especially, how activities are coordinated in an ecosystem. Also, little is known about inter-team coordination across firm boundaries. This becomes particularly problematic when the ecosystem consists of actors from various industries, accustomed with their own way of working. Paper III tries to fill this gap by investigating how Volvo, as a keystone actor, coordinates the activities in its ecosystem.

The findings illustrate the challenges faced by Volvo in coordinating development activities. Particularly, the paper highlights the problems faced by keystone actor in manufacturing industry. The fact that ecosystems for digitized products involve both hardware and software systems create coordination challenges related to development methods. The plan-driven development method (waterfall) is appropriate for value chain operations. However, Volvo's AD ecosystem included mostly technology firms that employed a change-driven (agile) development methodology. Paper III identifies synergies between agile development and coordinating activities in an ecosystem. It highlights the markedly improved coordination of different activities after Volvo's shift from a waterfall to agile development method.

### 5.4. Paper IV: The battle for keystone position: Exploring the competitive dynamics in an emerging innovation ecosystem.

The ecosystems literature identifies a four-phase lifecycle of birth, expansion, leadership and self-renewal (or death) (Dedehayir et al., 2018; Moore, 1993). There is growing interest in understanding the emergence (birth or pioneering) phase of an innovation ecosystem. Despite a consensus among scholars about the importance of the emergence phase, how the various actors interact during the different stages of ecosystem emergence is unclear.

Extant research identifies different activities distinct to ecosystem participants and how these activities evolve during the emergence of the ecosystem (e.g., (Dedehayir et al., 2018; Dedehayir and Seppänen, 2015; Iansiti and Levien, 2004b; Moore, 1993). This indicates that the keystone firm's activities may differ among these different periods. Paper IV investigates the challenges encountered by keystone actor during various phases of ecosystem emergence.

It employs the conceptual model developed by Dedehayir et al. (2018), which identifies various roles and activities, related to different periods of ecosystem emergence. The paper uses data collected from an emerging ecosystem around Volvo's AD platform.

The findings show that actors in Volvo's AD ecosystem both collaborate and compete – supposedly, a unique characteristic of an ecosystem (Granstrand and Holgersson, 2020; Hannah and Eisenhardt, 2018; Jacobides et al., 2018). In the incipient period of emergence, there is a clear division of tasks and responsibilities among the actors; the keystone firm copes with uncertainty and focuses on forging alliances, sharing resources and assign roles to the different actors. In the operation period, the keystone needs manage conflict and competition among the different actors.

The shifting balance between the keystone firm and the other actors, as the ecosystem develops, highlights the competitive dynamics in an innovation ecosystem. Paper IV also highlights the importance for the keystone firm, of developing the capabilities required to handle new challenges and threats. It identifies tensions between the keystone firm and other actors as value creation activities intensify.

# 6. Co-creating value in an ecosystem

*In this chapter, the main findings are discussed in relation to the research questions. First, the detailing of the case firm's section efforts to develop a new technology is depicted and then the role modularity on the emergence of an innovation ecosystem is highlighted. Finally, insights on co-creation of value in an emerging innovation ecosystem are discussed.*

## 6.1. Value co-creation during a period of DTC

Recent trends in the automotive industry, such as autonomous driving and electrification, have led to a dramatic increase in uncertainty in the industry. The shift from IC engines and manual control to BEVs with autonomous manoeuvring (see Figure 4), has triggered a new DTC cycle. The transition of Volvo's product platform to a technology platform, integrating hardware and software systems related to automated driving, helps to explain the process of value co-creation during a period of DTC. Thus, this sub-section builds on the findings from Papers I to IV, to address the first research question: *How do incumbents create value during a period of DTC*.

Traditionally, the automotive industry operated within an industry value chain, consisting of sequential flows of materials, components, information, etc. from one actor to another. The incumbent OEMs exerted dominance over the value chains through proprietary ownership of intellectual assets (Jacobides et al., 2016). Developing a new technology is problematic for incumbent firms which need to balance new stream and old stream innovations (see Assink, 2006). In the context of AD technology, the incumbent OEMs needed to develop both the vehicle platform and the digital systems and technologies needed to produce a fully autonomous car.

In the context of autonomous vehicles, value creation activities involve developing digital systems and software and, thus, involve integration of hardware and software (see Paper I). AD technology is a complex technological system, consisting of digital systems and components, and co-creation of the value proposition involving multiple actors from several industries (i.e., AD technology platform). Technological development involves integrating hardware and software systems on a base vehicle platform and interfaces among several systems and technologies. Paper I highlights the market and technology related issues experienced by Volvo as well as the lack of AD technology-related competences within the automotive industry. In traditional automotive OEM value chains, most alliance partners are tier 1 or tier 2 suppliers. Volvo's efforts to develop an autonomous car, started as an in-house NPD project. However, the complexity involved in developing the AD technology, and the lack of required resources and competences, promoted willingness on the part of the incumbent OEM, to engage with a diverse (and new) set of actors.

These multiple alliances introduced the need for standardized interfaces and definition of how the different components and sub-systems should interact. Paper II describes the alliances that were forged and how they influenced the technology platform architecture. For instance, increasing complexity and the need for more resources and competences in machine learning, sensor fusion, etc., pushed Volvo to externalize development of the software. Several of these alliance partners were non-automotive firms responsible for the production of components important for AD technology, such as Lidar, radar, cameras and GPUs – and software related to mapping and cloud services.

Paper II focused, especially, on the JV set up by Volvo to develop software for its AD technology. The decision to externalize AD software development had an important influence on the architecture of the technology. The decision to direct Zenuity to develop hardware agnostic AD software, implied a dual mandate for Zenuity: to do the application work for Volvo's AD platform and to develop a full AD software stack that could be commercialized to other OEMs. Note that, Zenuity did not own the critical hardware components and sub-systems; Volvo owned the hardware and relied on Zenuity to develop the software. The decision to spin out software development as an independent firm, but to retain all the hardware components inhouse is quite unique. It resulted in what can be described as a symbiotic relationship between Volvo and the newly minted JV (Zenuity). By externalizing software development to the JV partner, Volvo's AD platform shifted from being an internal platform to being an external platform (see Paper II). To make this rather unique partnership work, Volvo and Zenuity were forced to synchronize their development activities and design seamless interfacing between hardware and software. Overall, Paper II shows how the alliances forged during a period of DTC, transformed Volvo's internal platform into an external modular platform (c.f. (Gawer and Cusumano, 2014).

Paper II shows that the decision to outsource core software development implicitly modularized Volvo's AD platform, which would not have happened otherwise. However, the interface between the AD hardware and software was situated outside of Volvo which meant that Volvo's technology suppliers and other alliance partners were forced to cooperate with an additional actor. Despite the challenges related to interfacing with multiple actors, Volvo received some benefits. Also, in addition to the interface with the software firm (Zenuity), Volvo's AD platform had numerous other interfaces with sub-systems and complementary technologies, underscoring inter- and intra-industry collaboration. Thus, value creation activities were taking place in an inter-organizational network consisting of a diverse set of actors. This way of co-creating value is unique to the automotive industry (c.f. Jacobides et al., 2016).

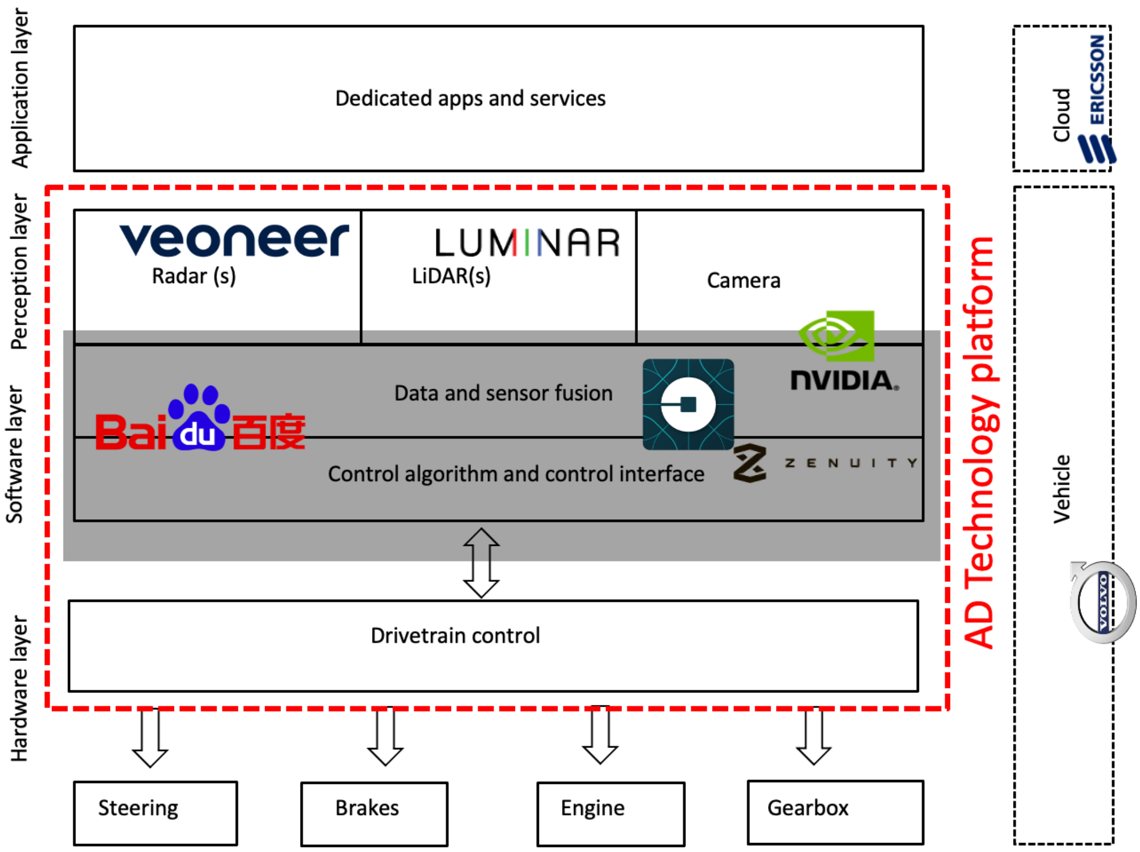


**Figure 4**. Interfaces between layers, along with actors, in Volvo's AD technology (Source: author)

The AD technology, a DTC for the automotive industry necessitates collaborations beyond developing the core technology, for instance, to develop the standards – for autonomous vehicles – the OEMs need to engage with government agencies, international institutes, and other socio-economic entities. In view of this, Volvo forged alliances with multiple technology firms, industry consortia and other actors such as universities, government agencies and start-ups (see Paper II). This allowed it to construct a complex inter-organizational network in which participants needed to align their activities at both the firm, network and system-levels. Volvo's AD technology platform does not resemble previous automotive industry platforms. Like most OEMs, Volvo used modularity to outsource, but continued to control the interface, that is, what goes into the vehicle, and the hierarchical control over the value chain (c.f. Jacobides et al., 2016). To develop the AD technology, Volvo and its alliance partners (from within and outside the automotive industry), co-created value in an inter-organizational network consisting of specialized firms from multiple industries (see Figure 4).

### 6.2. Modularity and innovation ecosystems

The ecosystem literature includes extensive studies of the underlying mechanisms that allow the actors to co-create value (Gawer and Cusumano, 2014; Jacobides et al., 2018). It is widely accepted that modularity is an important prerequisite for the emergence of an ecosystem. However, few studies distinguish between modularity in the context of traditional industries (Argyres and Bigelow, 2010; Baldwin) and modularity that facilitates value co-creation in an ecosystem (Thomas et al., 2022). Therefore, this section addresses the second research question: *What is the role of modularity in the emergence of an innovation ecosystem?*

Paper II describes the evolution of an OEM AD platform, from an internal firm-specific platform to a modular external platform. The modular AD platform facilitated value co-creation (see Paper II). The modularization of Volvo's AD platform was the outcome of different sub-systems and technologies and their inter-operability to achieve functioning of a driverless car (see Figure 4). From a value creation perspective, the development of a modular platform had important implications for Volvo's ability to co-create value. This was because the AD technology platform consisted of hardware and software layers built upon a base car platform (i.e., vehicle platform).

It should be noted that the modular architecture of Volvo's AD technology platform was distinctly different from previous 'modular' platforms (c.f. (Jacobides et al., 2016). This modular architecture, achieved during a period of DTC, facilitated integration of new technologies and systems while previous automotive modular platforms enabled outsourcing and asset shedding. This modular architecture builds on a different logic; the AD technology is an overlay on the OEM's base car platform. This can be compared to the example of PCs, where OEMs developed the computer mainframe (or CPU), which integrated components such as the GPU, modem and memory. The hardware layer hosts the software layer, consisting of the operating system, to process data and perform computations and tasks. In turn, the operating systems hosts the application layer, which provides specific features that help the user accomplish a task and solve problems. Thus, developing an AD technology platform required several firms co-creating the necessary systems and features, at multiple layers.

A modularized platform allows innovation to be split across multiple firms (see Tiwana, 2015). Paper II discusses the concept of layered modularity and provides new insights into how this facilitates value co-creation activities involving both hardware and software systems. The study of layered modularity builds conceptually on the works of Autio et al. (2016) and Yoo et al., 2010), but differs in the way it is used in the context of industrial firms transitioning their product platforms into technology platforms. Papers I and II both show that the innovation activities related to developing AD technology, took place outside the traditional OEM value chain. This co-creation of value, in an inter-organizational network, is analogous to an innovation ecosystem.

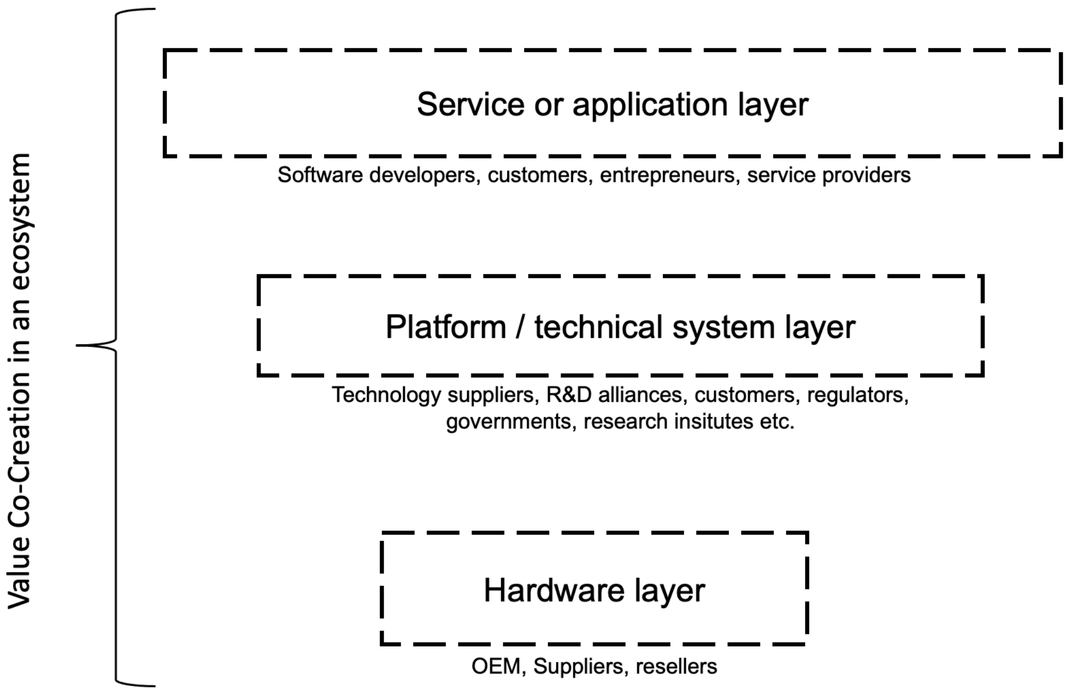


**Figure 5.** Generic schema of 'layered' modularity in the AD ecosystem (Source: author)

Although modularity allows co-creation of value, interfaces are required to guarantee interoperability. The interface between Volvo's hardware platform and Zenuity's software was particularly important (see Figure 4). Paper II describes the challenges faced by Volvo to integrate different layers onto its car platform. To build the base vehicle platform (i.e., hardware or device layer), Volvo operated within the traditional automotive value chain. For the AD layer, Volvo collaborated with technology firms with expertise in sensor systems, lidar, distributed computing, etc. (see Figure 4). Also, Volvo relied on Zenuity to develop the AD software stack and collaborated with providers of cloud services, navigation technology and infotainment systems, and with university research centres and government sponsored research organizations. Over time, Volvo set up several collaborations (see Paper II), all aimed at facilitating development and commercialization of AD vehicles (see Figures 4 and 5).

The AD programme at Volvo involved a network of actors co-creating value around a focal value proposition (i.e., AD technology platform). The process of value co-creation in an ecosystem is both similar and different from the creation of value in networks (Bouncken et al., 2020; Normann and Ramírez, 1993; Peppard and Rylander, 2006), innovation systems (Cooke et al., 1997; Lundvall, 1992b) and innovation networks (Dhanara and Parkhe, 2006). However, t process of value co-creation that includes elements, such as non-hierarchical organizing of activities, generating non-generic complementarities, network effects and knowledge sharing, when considered in isolation, is not unique to ecosystems. It is the combination of these elements which distinguishes them from other collective value creation structures described in the literature (see Thomas et al., 2022)

The value creation activities, related to the AD technology, took place outside Volvo's boundaries, and required coordination amongst multiple actors. Paper III discusses Volvo's interactions with the different partner firms and the coordination challenges involved in co-creating value. On one hand, Volvo controlled the interfaces between the different sensors and components and owned the hardware architecture. On the other hand, Zenuity developed everything between the sensors (i.e., software), but had no control over the hardware architecture. In other words, the interface between the hardware and software was outside Volvo's boundaries, which increased the complexity of coordination. Paper IV highlights these coordination problems and the need for seamless interfacing between the hardware (developed by Volvo) and the software (developed by Zenuity). At the same time, Volvo and Zenuity had partnerships with numerous other actors.

Paper III describes the issues related to Volvo's waterfall development method and Zenuity's agile working and the resulting coordination problems. Paper III addresses Volvo's role as coordinator of activities and illustrate the usefulness of agile methods for coordinating activities in an ecosystem. In the early stages of the ecosystem studied, the keystone firm was setting up alliances to facilitate value co-creation. During this period, the actors were exploring ways to cooperate and to exchange resources and competences. Thus, the primary focus was on cooperating and coordinating. However, as the ecosystem developed and value creation activities became more prominent, some actors exhibited competitive behaviour (see Paper IV). Paper III provides insights into the differences in how Volvo and the other actors in the ecosystem worked.

Zenuity's lack of freedom and it dependence on Volvo for the sensor systems and the base car platform, had a severe effect on the ecosystem (see Paper IV). Also, Zenuity's hardware agnostic AD software developments were pitted against the products of other actors in Volvo's ecosystem. Thus, after it established the JV, Volve became responsible for managing the competition among its suppliers and complementors. Paper IV highlights the increasing tensions between Volvo and Zenuity. Paper III identifies how transformation to agile working improved the coordination among the actors in the ecosystem. Paper IV shows that Volvo allowed Zenuity to develop hardware agnostic software but controlled the hardware architecture and the interfaces between the components and the systems. Zenuity's lack of ownership of the hardware platform meant that Zenuity's software developments relied on access to Volvo's base car platform. Zenuity was responsible, also, for developing the software for both the AD and ADAS systems.

### 6.3. Orchestrating an emerging innovation ecosystem

Developing AD technology on a digital platform, involves co-creating value within a complex inter-organizational network. Several scholars use the innovation ecosystem concept to describe the process of joint value creation, involving firms across industries and countries, with relative lack of hierarchical relationships or contracts (Adner and Kapoor, 2010a; Thomas et al., 2022). This section is related to the third research question: *How can an incumbent firm orchestrate the emergence of an innovation ecosystem?*

Taken together, the appended papers highlight how Volvo exploited a period of DTC in the automotive industry, to establish alliances, and how it engaged in a non-linear process of value creation within an innovation ecosystem (see (Adner and Kapoor, 2010a; Russell and Smorodinskaya, 2018). The findings in the appended papers highlight three important activities related to Volvo's orchestration of the emerging ecosystem, namely *cooperation, coordination,* and *competition*. While none of these activities, in isolation, is unique to an ecosystem, the coopetition within the network and lack of hierarchical coordination, distinguish it from other collective value-producing structures described in the management literature (see Thomas et al., 2022). Together, these activities highlight Volvo's transition from an OEM to the keystone firm in the emerging ecosystem.

First, *cooperation* in the form of alliances and partnerships, to develop AD technology, led to the evolution of Volvo's internal platform into a modular external platform (see Paper II). Lack of resources and competences to develop the technology, prompted Volvo to cooperate with other firms. This cooperation involved not just suppliers and complementors but also government regulators and industry bodies. Paper II shows that developing the AD technology involved continuous engineering and data-driven innovation, where functions and features are developed based on real-world data. To achieve this, Volvo cooperated with a diverse set of actors, including automotive firms, technology firms, institutions and competitors. A feature of the AD technology is that it requires continuous testing and validation of its functions and vehicle performance in real-word traffic. This required cooperation with the regulator and the traffic authorities to obtain approvals and certifications (see Paper I). The AD technology, which represented a DTC in the automotive industry, required a reconfiguration of the transport infrastructure and standards to enable its commercialization. It is not an industry specific innovation; rather, it requires cooperation among a number of industry actors, technologies and national and international institutions. Papers I and II discuss the cooperation that took place at many levels related to distinct systems and features.

Paper II discusses the transition of Volvo's AD programme to an innovation ecosystem, consisting of both the production and user sides, including suppliers, customers, complementors, competitors, universities, regulators and standards-setting bodies. This involved a cooperation network to enable multiple actors to co-create value. From an ecosystem perspective, a cooperation strategy allows independent actors to focus on one or few components in a technology or platform, and depend on other actors for the remaining components (see (Hannah and Eisenhardt, 2018). Cooperation facilitates the emergence of an ecosystem, led by a keystone actor that manages the cooperation. Paper II shows that the concept of layered modularity allows heterogenous actors to cooperate and develop non-generic (or super modular) complementarities. A multi-layered innovation ecosystem model allows industrial firms to operate in distinct layers (Visscher et al., 2021).

Second, *coordination* enables synchronization of the activities. In Phase B of the longitudinal study, the AD ecosystem value creation operations intensified, which called for appropriate mechanisms to coordinate the activities occurring in the multiple layers. To co-create a complex value proposition, such as AD technology, in an ecosystem that includes diverse actors, requires mechanisms to coordinate development activities at both the firm and network- or system levels Papers III and IV show that, as Volvo's AD ecosystem expanded, it became more and more difficult to coordinate activities. Here, it is pertinent to highlight that Volvo externalized its AD software, but not the AD hardware development (see Papers II and III). This is comparable to Amazon  setting up a subsidiary to establish a cloud business such as Amazon Web Services, but retaining the servers within the parent firm. The separation of hardware development and software development, between Volvo and Zenuity, raised additional coordination challenges (see Paper III). Volvo's waterfall work plan was ill-suited to coordinating activities related to software development.

Third, *competition* occurred over important positions and increased competitive advantage. Developing the AD technology resembles a natural ecosystem in which populations of diverse organisms *cooperate* and *compete* (see Hannah and Eisenhardt, 2018), exhibit symbiotic relationships (see Davis and Eisenhardt, 2011), but also fierce competition. In natural ecosystems it is also common for organisms to *coordinate* their activities (see Bshary, Hohner and Ait-el-Djoudi, 2006).  In the context of the automotive industry, the presence of competing actors in the same network is peculiar. The study by Jacobides et al. (2016), on modularity and outsourcing in the automotive industry, highlights the persistence of  the OEMs' hierarchically managed value chains despite pioneering modularity and outsourcing. The hierarchical industry structure and modules with closed standards on an OEM-proprietary base, meant that outsourcing did not result in the modular open-access segments which occurred in the PC sector. Jacobides et al. (2016) studied modularity and outsourcing in the automotive industry and highlight the persistence of the OEMs' hierarchically managed value chains despite being pioneers of modularity and outsourcing. The OEMs controlled the value chains, leaving little room for competitors to co-create value or partner in the innovation activities. The OEMs controlled the value chains, leaving little room for competitors to co-create value or partner in the innovation activities.

In Table 8 below, an overview of the identified activities identified during the emergence of the ecosystem are summarized, as well as the role of the keystone, and the main mechanisms underpinning the activities.

**Table 8.** Overview of important activities identified during the emergence of an ecosystem

| | Cooperation | Coordination | Competition |
|---|---|---|---|
| **Associated concepts** | Alliances, discontinuous technological change, new product development | Open innovation, Agile development method | Platform management, layered modularity, |
| **Main mechanism underpinning the activity** | Value co-creation | Synchronize activities and development plans | Capturing and sharing value |
| **Keystone role** | Accumulate resources and competences | Establish roles and routines | Manage conflicts and promoting actors |
| **Mapping to appended papers** | Paper I, II | Paper II, III | Paper III, IV |
| **Related sources** | Ceccagnoli et al. (2012), Adner and Kapoor (2010) | Brusoni (2013); (Williamson and De Meyer, 2012a, b) | Cennamo (2021), Ritala et al. (2018) |

# 7. Becoming a keystone

*In this chapter the concept of 'layered modularity', and its role in the emergence of an innovation ecosystem, is introduced and discussed. This is followed by a discussion on important activities related to the orchestration of an ecosystem. Furthermore, the chapter highlights the capabilities needed to orchestrate an ecosystem and become the keystone actor.*

## 7.1. The role of layered modularity in ecosystem emergence

Industrial economy scholars use the concept of value chain to analyse the links between different industry activities. However, many firms are co-producing value with multiple economic actors from different regions and industries. Several studies examine the process of joint value creation and appropriation in ecosystems, with particular emphasis on the structure and dynamics of the ecosystem (Adner and Kapoor, 2010; Jacobides et al., 2018; Thomas and Autio, 2013). Some works focus on network orchestration and ecosystem growth, but overlook the process of ecosystem emergence (Thomas et al., 2022).

Ecosystem scholars find modularity as an important attribute that facilitates the development of non-generic complementarities and subsequently lead to the emergence of an ecosystem (Gawer and Cusumano, 2014; Jacobides et al., 2018; Thomas and Autio, 2018). A few studies, such as Thomas et al. (2022), explain the process of ecosystem emergence, but do not show empirically how modularity leads to the emergence of an ecosystem. Jacobides et al. (2018) contribute by suggesting that modularity allows for development of non-generic complementarities, identified by Adner (2006) as uniquely characteristic of an innovation ecosystem. However, so far, none of these works explain how and when modularity translates into or generates 'non-generic' complementarities. This is because not all modular platforms or products result in the emergence of an ecosystem. This might be because established firms in traditional industries, use modularity to outsource and shed assets while retaining their dominance in the industry value chain (Jacobides et al., 2016).

Manufacturing firms use modularization (or a modular product architecture) to achieve strategic flexibility and reduce coordination and integration costs (Magnusson and Pasche, 2014). Due to the rapid advancements in ICTs and the increase in IoT platforms, manufacturing firms need to focus on more than development of physical goods (Yoo et al., 2010). They need to use specific architectures that combine modularity of physical goods with a layered software architecture (Hodapp et al., 2019). In this context, the concept of layered modularity is useful as a design mechanism that allows distinguishing between developing physical products and digital systems. Yoo et al. (2010, p. 725) describe the *layered modular architecture* as a "hybrid of the modular architecture of a physical product and the layered architecture of digital technology". As already mentioned, modularity as understood in the traditional product development literature, differs from modularization which facilitates co-creation of value during a period of DTC. Modularity, according to (Baldwin, 1997), gains prominence as a technology matures and profits are eroded (see Figure 6) and  modularization allows the firm to reduce its assets and do less.

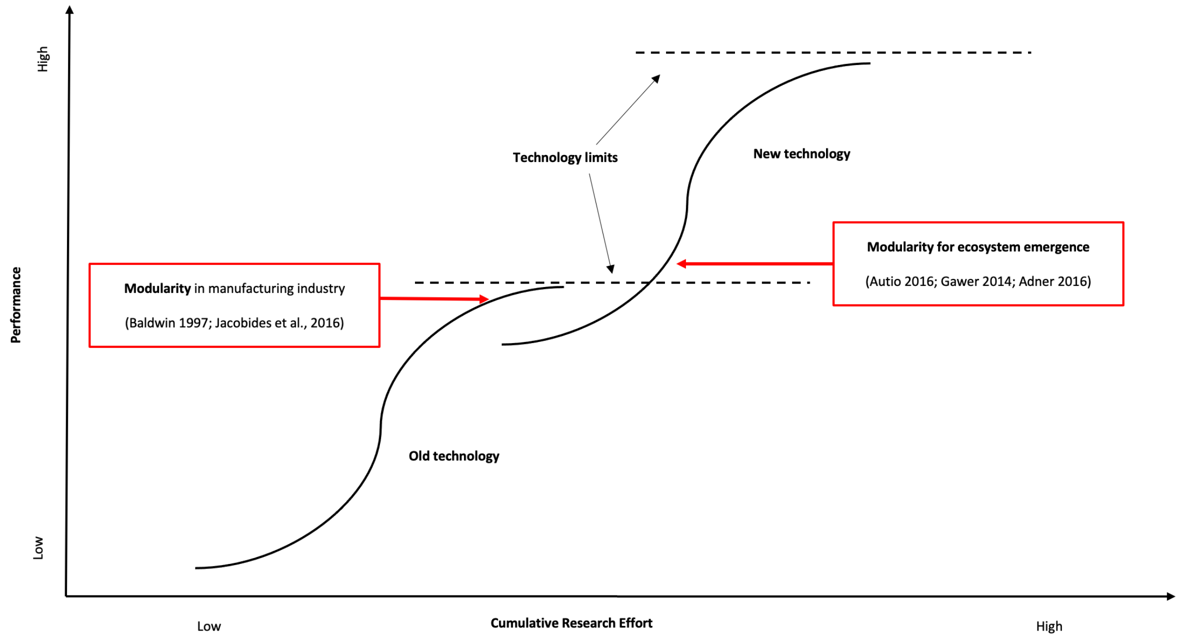


**Figure 6:** The use of modularity explained using technology s-curve (Source: author)

For instance, in the automotive industry, modularity is usually associated with vertical disintegration and the scaling of product platforms (Argyres and Bigelow, 2010). However, the modularity described by Jacobides et al. (2018) that is needed to enable emergence of an ecosystem, is different. Here, platform (or artifact) modularization facilitates generation of mutual value for the actors. Thus, in developing new technologies, the OEMs need to develop both the vehicle platform and the technology platform. In the former development, the modular hardware platform allows the OEM to outsource and expand product variations. In the case of digital technologies, modular platforms facilitates value co-creation and the generation of complementary innovations.

Some scholars discuss the importance of generativity (see REMNELAND-WIKHAMN et al., 2011), but do not explain the design mechanisms to stimulate generativity. Understanding the role of generativity is especially important for the Internet of Things (IoT) platforms, which require the efforts of several actors to develop interoperability among devices, platforms and standards (Hodapp et al., 2019). In a strand of the information systems literature, the notion of "layered modular architecture" is used to explain "generativity" related to digital innovation.

This thesis argues that, in the case of firms that build physical products with digitized features and functions, such as autonomous cars, layered modularity is becoming essential. Previous works by Information Systems (IS) scholars (see Yoo et al., 2010; Gao and Iyer 2006) discuss layered modular architecture, but not its implications for industrial products undergoing digitalization.  With the exception of Autio et al. (2016), most studies do not identify layered modularity as important to facilitate generation of non-generic complementarities. This may be because IS scholars study digital artifacts, such as software and digital platforms, where there is no distinction between the hardware (or device) and the software (or service) (Altman et al., 2021).

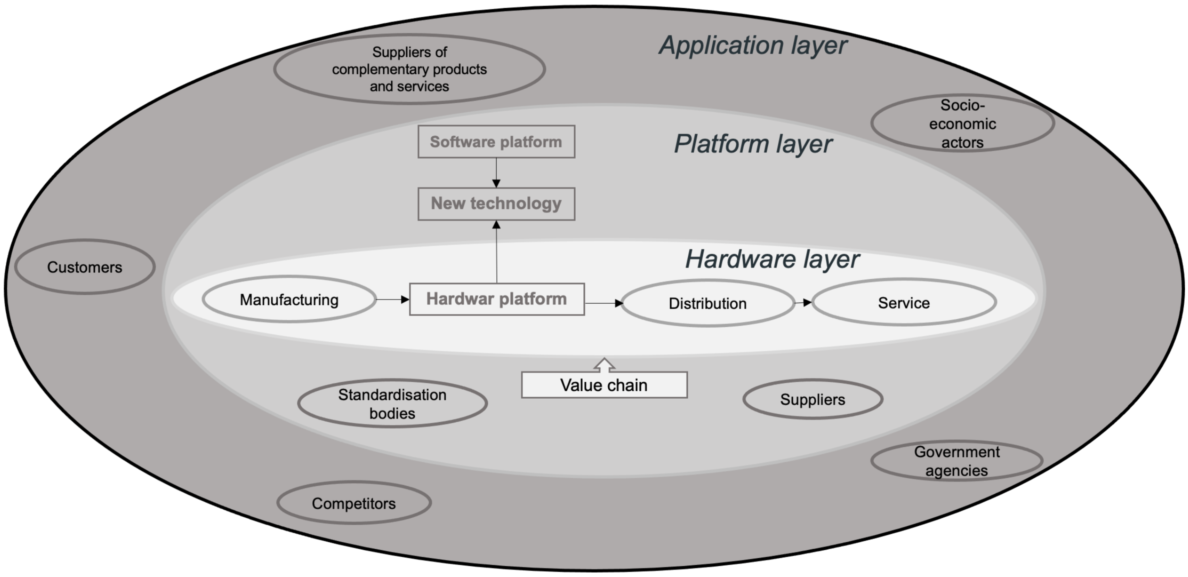


**Figure 7**: Layered modularity and ecosystem value co-creation (Source: Author)

This thesis discusses the subtle, but important difference between modularity for outsourcing and vertical disintegration (Argyres and Bigelow, 2010; Jacobides et al., 2016) and modularity for co-creating value in an ecosystem. Several mechanisms have been proposed to explain how firms co-create value. Here, the thesis explores the role of 'layered modular architecture' in the process of ecosystem emergence (see Yoo et al., 2010). Layered modularity allows *cooperation, coordination,* and *competition* among the actors and resembles a natural ecosystem facilitating the serendipitous evolution of actors, activities and artifacts (see Figure 7).

### 7.2. Orchestrating an emerging ecosystem

In the digital economy, where products and services are digitalized, the boundaries between physical and digital are disappearing and innovation is no longer a firm or industry specific activity. The future of industrial production involves not just development of physical products and related services. In contrast to physical products, digital products (such as smartphones) are characterized by generativity and continuous creation of value based on the ability to allow users to access and consume other digital products and services (Autio et al., 2016). This thesis argues that designing distinct modular layers enables the keystone to manage coopetition and balance in the ecosystem between generativity and alignment.

This thesis presents important ways through which a keystone orchestrates an ecosystem. The activities begin with *cooperation*, leading to the emergence of an ecosystem. This is then followed by *coordination* to synchronise the development actors performed by independent actors. Following this, the keystone needs to manage the *competition* that arises due to each actor aiming to establish dominance and maximize its value capture potential.

### *7.2.1. Cooperation*

Innovation is an increasingly distributed and collective process requiring cross-industry and cross-country cooperation (Brusoni, 2013). During a DTC, development of a knowledge base or of technological competences can be difficult, time consuming and expensive (Lambe and Spekman, 1997). Inevitably, the uncertainty inherent during a technological change pushes the incumbents to cooperate with other firms in order to accumulate resource and competences (Bergek et al., 2013; Lambe and Spekman, 1997). This thesis suggests that, in this situation, incumbent firms are more willing to cooperate with firms from outside the industry and even with potential competitors.

Iansiti and Levien (2004b) identify specific roles for the members of an ecosystem and highlight the importance of the 'keystone species', that is, the actor that facilitates value co-creation. It seems that the presence of one or a group of actors that ensure that all system members cooperate rather than focusing on their internal operations, is vital for ecosystem success. Cooperation in an ecosystem tends to become established around a focal firm or technology and research on platforms and ecosystems, highlights the importance of the interfaces between the actors and the artifact (or focal value proposition). These interfaces allow cooperation among different actors without the need for contracts or hierarchical relationships. The development of these interfaces depends on cooperation among individual firms to construct technology blueprints, design the interfaces between systems and standardize the interaction among distinct modules. Brusoni and Prencipe (2013) identify "ambiguity, complexity, and uncertainty as key features of the problems that the focal organization must solve in order to carry out its strategic and operational tasks."

This thesis argues that layered modularity facilitates cooperation and is an important design instrument for an incumbent firm in the transition of industrial-age production into a platform (c.f. Jacobides, 2006). Extant research has examined the role of platform leader or keystone for facilitating cooperation. However, these studies consider either actors operating in existing ecosystems (such as Apple in the iOS ecosystem and Intel in the PC ecosystem) or actors developing software products such as open-source consortiums (Linux foundation, Apache Software foundation) (see Altman et al., 2021). A technology platform with multiple layers of modularity, allows incumbents in traditional industries to facilitate cooperation involving diverse actors in diverse layers. A layered modular architecture (c.f. (Autio et al., 2016; Yoo et al., 2010) allows manufacturing firms to integrate digital functions and features in their physical product.

### *7.2.2. Coordination*

An ecosystem emerges due to cooperation between heterogenous actors. For the ecosystem to grow and materialize, there is a significant need for coordination (see Jacobides et al., 2018, p. 2260). Coordination is essential to synchronize the activities of a group of diverse actors and integrate distributed information, knowledge and competences related to new products or technologies. According to Furr et al. (2018, p. 59-60), ecosystems need more than a broker or intermediary to coordinate the different actors and establish the rules of engagement.

Coordination is more difficult in the case of an ecosystem that emerges around physical platform (such as a vehicle platform or phone platform) expanding to integrate digital technologies and services. This involves developing hardware and software simultaneously (see figure 5). The actors involved with developing hardware and software are accustomed to different ways of working. Although manufacturing firms are well known to develop software, e.g., a digital camera or television consists of pre-installed software from the manufacturer, they still use structured development methodologies to develop software (see Yoo et al., 2010, p. 732-733). As manufacturing firms increasingly leverage IT to develop digitized products, the need to create loose couplings across devices, networks and services. To extend physical products into platforms, that facilitate network-based exchanges, firms need to share data, exchange protocols and associated interfaces. This involves governance and coordination mechanisms that facilitate development activities.

This thesis proposes agile development methods as a way to facilitate the keystone's coordination of activities related to a complex technology or product. Agile methodology allows the actors to adapt when faced with new problems and to integrate new activities to satisfy the requirements of others in the ecosystem. Thus, the thesis argues that keystone need capabilities to employ agile development methods, in developing software or digital system. However, this becomes difficult for manufacturing firms that need to balance between hardware and software development. Manufacturing firms tend to operate in industry value chains according to the waterfall work plan. In digital ecosystems, the participants work according to feature-driven or agile development. In this regard, a layered modular architecture enables coordination of both hardware and software development activities. In the case of base hardware, the keystone can exploit its existing industry value chain management capabilities. However, to manage the activities related to the software and/or application layers (see Figure 5), the keystone needs to employ agile methods to coordinate software development activities. Modularity reduces frictional transaction costs allowing for cooperation and, subsequently, value co-creation in an ecosystem. This thesis discusses the coordination issues faced by an incumbent firm. The emerging ecosystem consists of actors with divergent ways of working. The keystone firm recognized that coordination would require flexibility and adaptability.

### 7.2.3. *Competition*

The ecosystem literature examines competition among actors who create value in relation to a shared context, common purpose and common value proposition (Adner, 2017; Moore, 1993; Alain et al., 2019). Similar to biological ecosystems, the participants act both cooperatively and competitively, in order to create value (Brusoni and Prencipe, 2013).

Competition in the ecosystem fosters innovation and provides fertile ground for firm renewal and evolution over time (Dedehayir et al., 2018). Ritala (2019) argues that coopetition alliances help the focal firms to increase their competitive capabilities. There are several empirical examples of ecosystems that depend on both the collaboration and competition of the actors (e.g., Rohrbeck et al., 2009; Gawer, 2014; Mantovani and Ruiz-Aliseda, 2016; Hannah and Eisenhardt, 2018). It should be noted, however, that artifacts that use competing technologies or standards, provide the end customer with greater value (see Granstrand and Holgersson (2020).

It has been argued that keystone firms or platform owners may selectively promote or support certain ecosystem actors (Rietveld et al., 2019). This behaviour can trigger conflicts among the actors; mis-managing competitive activities may be detrimental to the entire ecosystem. Alain et al., (2019) recommend longitudinal analysis to explain the impact of coopetition capabilities (or the lack of it) on the emergence, evolution and decline of an ecosystem.

The thesis highlights the challenges faced by incumbents in managing cooperation and competition among ecosystem members. Traditionally, conflicts were managed by hierarchical mechanisms (such as contracts) (see (Jacobides et al., 2016). However, in an ecosystem context, there are neither hierarchies nor contracts (see Thomas & Ritala, 2021). Technological and market uncertainties contribute to making technology development cumbersome and frustrating (Ahuja, 2000).

## 7.3. Keystone capabilities

Few empirical studies focus on how incumbent firms can develop the capabilities to orchestrate the emergence of an ecosystem and establish itself as the keystone actor (Altman et al., 2021). The lack of scholarly discourse on co-creation of value in an ecosystem, by incumbent firms, constitutes a major gap since increasingly more industries are likely to make the transition from industry-specific value chains to co-creation of value in ecosystems. We know little about how incumbent firms can augment their capabilities to enable them to organize an emerging ecosystem and establish themselves as the keystone or leader of that system (Aarikka-Stenroos and Ritala, 2017; Furr and Shipilov, 2018; Poblete et al., 2022). Unlike new entrants and start-ups, to accumulate these capabilities requires incumbent firms to adapt and to learn see(see Altman et al., 2021). Incumbent firms, from manufacturing industries, possess organizational capabilities related to their resource base, intellectual assets and hierarchical industry structure. They need to adapt their capabilities to the digital era that requires heterogenous actors to assimilate distributed resources, competences and organize value creation activities without a hierarchical industry structure.  The capabilities required are discussed in the following subsections.

Extant research on ecosystems, primarily investigates orchestration capabilities from the perspective of technology firms or new entrants spawned within an ecosystem (e.g., Apple and iOS, Amazon and Prime video). The capability to initiate cooperation with diverse actors marks the process of  joint value creation in an ecosystem. However, to orchestrate the value co-creation activities, it is necessary to develop routines and methods to exchange resources and competences. In contrast to industrial products, digital devices (such as smartphones and smart speakers) are characterized by generativity and continuous creation of value. Generativity related to digital technologies means that value is created continuously through unexpected combinations and unpredictable innovations. The thesis argues that 'layered modularity' facilitates co-creation of value in multiple layers and allows cooperation and coordination of distinct activities within an ecosystem. It highlights how layered modularity facilitates generativity, by enabling both cooperation and competition amongst actors, leading to the development of nongeneric complementarities.

The notion of ecosystem synonymizes organic and serendipitous development, yet, it is common for industrial ecosystems to be managed and orchestrated by a central keystone actor (Poblete et al., 2022). The idea of capabilities is used in various strands of the strategic management and business economics literature; several works explore organizational capabilities, to describe how firms establish competitive advantage e.g., (Barney, 2001; Teece, 2007; Teece et al., 1997). However, how firms develop the capabilities to orchestrate or manage an emerging ecosystem, and become the leader of that ecosystem, remains unclear.

This thesis argues that firms that intend to take the keystone role need to develop new capabilities to enable co-creating value in an ecosystem (see Figure 8). This thesis proposes three keystone capabilities – cooperation, coordination and competition capabilities – that are important for orchestrating an emerging ecosystem.

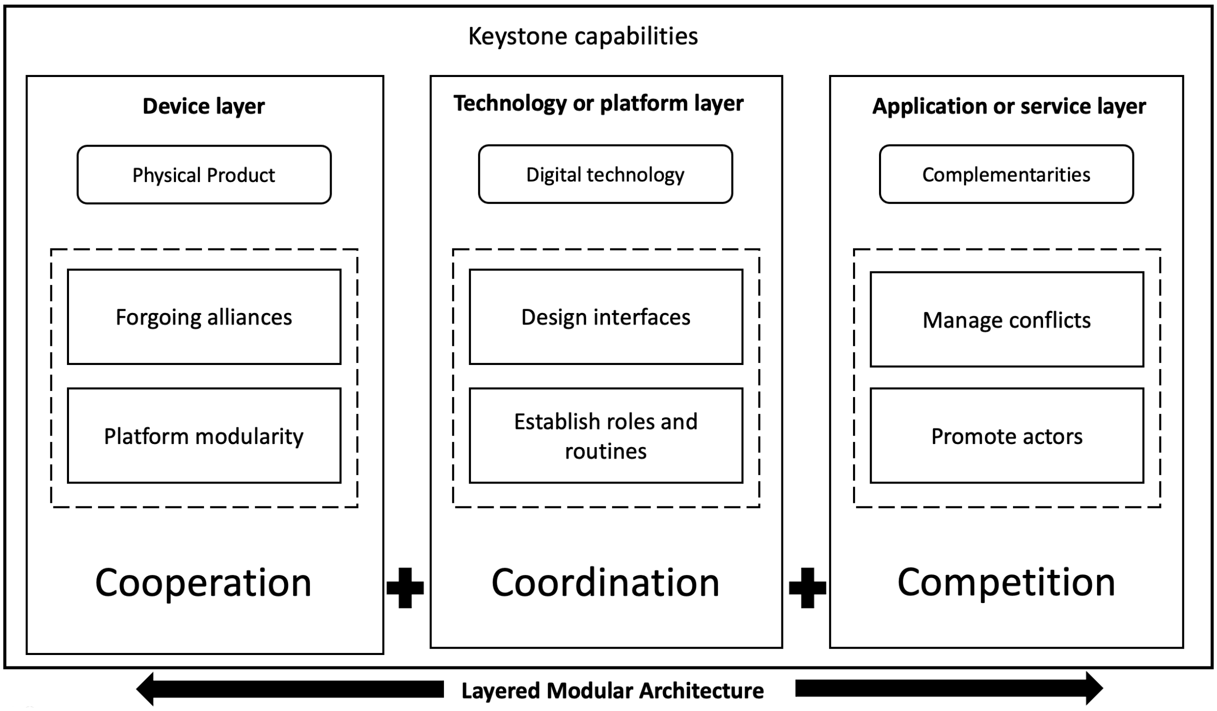


**Figure 8:** The three keystone capabilities for ecosystem orchestration (Source: author)

This thesis explains how new types of cooperation leads to the emergence of an ecosystem. Afterwards, the keystone needs to develop methods and tools to coordinate the activities. Here, the agile development methodologies facilitate the keystone actor to manage the interaction and plan development activities. The coordination of the activities enables independent actors to co-create value for the ecosystem.

As value co-creation intensifies, it is also expected that some actors will compete with each other as well as with the keystone actor. Incumbent manufacturing firms reduce competition with hierarchical structure and contracts. However, competition is instrumental for generativity in an ecosystem. Therefore, instead of avoiding competition, the keystone needs to develop capabilities to manage competition to support the ecosystem.

# 8. Conclusions and implications

*This chapter presents the main conclusions of this thesis as well as the contributions to theory and practice. Also, some directions for future research are suggested.*

## 8.1. Conclusion

The purpose of this thesis has been to explore how incumbents leverage a technological change to create ecosystems. In this context, this thesis investigated an incumbent manufacturer's activities related to developing a new technology. Based on a longitudinal case study, this thesis contributes to literature on innovation ecosystem in the following ways.

First, the thesis shows that incumbents establish alliances more broadly when facing a DTC. The findings show the collective processes and nature of alliances that lead to the transition of an 'internal' firm specific platform to an 'externalized' modular platform.

Second, this thesis proposes that a layered modular architecture, for industrial platforms can be used as a design mechanism that supports the manufacturing of industrial products with digitized functions. Further, the thesis argues that layered modularity facilitates generativity. By separating activities related to hardware and software development in different layers, industrial manufacturers can delineate between cooperation and competition.

Finally, the thesis identifies three capabilities that a keystone firm needs to orchestrate an emerging ecosystem, namely cooperation, coordination, and competition capabilities. The thesis also outlines some activities related to these capabilities. Thus, the thesis highlights how manufacturing firms can develop capabilities to orchestrate value co-creation in an ecosystem.

## 8.2. Contributions to literature

The thesis contributes to scholarly discourse on innovation ecosystems by explaining the transition of an incumbent firm's internal platform onto an 'external' modular platform. The resulting modularization highlights an important distinction between modularity as understood in the traditional product development literature and modularity as understood by ecosystem scholars. Extant research on ecosystems, acknowledges that modularity and nongeneric complementarities are their important underpinnings (Gawer and Cusumano, 2014; Jacobides et al., 2018). However, there is a gap in our understanding of the process of ecosystem emergence (Thomas et al., 2022). Thus, the thesis discusses the co-creation of value in the automotive industry by examining one case, a large industrial manufacturer developing a technology platform during a period of DTC.

The future of industrial production involves not just developing physical products and related services. In contrast to physical products, digitized products (such as smartphones) are characterized by generativity and continuous creation of value based on the ability to allow users to access and consume other digital products and services (Autio et al., 2016). This thesis proposes the idea of layered modularity as a mechanism to support development of digital technologies. It shows how layered modularity facilitates generativity.

Previously, manufacturing firms used their manufacturing capabilities, resources, etc. to establish their position in the value chain. Today, value creation is becoming much larger than an individual firm or even an industry. Also, ecosystem scholars do not explain the capabilities need to orchestrate value creation in an ecosystem consisting of both hardware and software systems. Few empirical investigations investigate how incumbent firms can develop the capabilities to orchestrate an ecosystem and become the keystone actor (c.f. Altman et al., 2021). The keystone capabilities to orchestrate an ecosystem, presented in this thesis relate to incumbent (manufacturing) firms extending their industrial products into digital platforms.

## 8.3. Managerial implications

The findings in this thesis have important implications for industrial manufacturers seeking to extend their product platforms into industrial ecosystems. It is of relevance for managers and executives in incumbent manufacturing firms interested in developing digitized products and services. Incumbent firms are accustomed to operating in linear value chains with hierarchical organizing logic. With advancements in ICT, the organizing logic is moving away from integrated architecture, with one-to-one coupling between components, towards modular architecture with standardised interfaces.

A layered modular architecture allows managers to organize innovation activities across multiple layers. This allows manufacturing firms to balance between the vertically integrated hierarchy of industrial value chain and vertically disintegrated value network of digital technologies. With developing the physical product (such as a car or a camera), the incumbent firms can innovate within their existing hierarchies and traditional development methods. To develop digitized functions and features, managers can leverage the device (or hardware) layer to integrate software and technologies created by heterogenous firms, thereby intertwining a range of innovation trajectories. At the technology (or application layer), incumbents can employ agile development methods to cope with the uncertainty and rapid pace of software development.

## 8.4. Future research

Despite the usefulness of a single longitudinal case study, more data across multiple cases is called for. In this thesis, the ecosystem studied was explored from the perspective of an incumbent firm in the automotive industry. Studying the automotive ecosystem from the perspectives of new entrants could yield complementary insights. Further, the keystone actor capabilities discussed in this thesis is based on an emerging ecosystem. As ecosystems evolve, grow and mature, there may be a need for other critical keystone actor capabilities. This perhaps may lead to an understanding of keystone capabilities over an ecosystem lifecycle which may be an exciting area for future research.

# 9. References


Aarikka-Stenroos, L., & Ritala, P. (2017). Network management in the era of ecosystems: Systematic review and management framework. *Industrial Marketing Management, 67*(Supplement C), 23-36. doi:https://doi.org/10.1016/j.indmarman.2017.08.010

Adner, R. (2006). Match your innovation strategy to your innovation ecosystem. *Harvard business review, 84*(4), 98.

Adner, R. (2017). Ecosystem as Structure:An Actionable Construct for Strategy. *Journal of Management, 43*(1), 39-58. doi:10.1177/0149206316678451

Adner, R., & Kapoor, R. (2010). Value creation in innovation ecosystems: how the structure of technological interdependence affects firm performance in new technology generations. *Strategic Management Journal, 31*(3), 306-333. doi:10.1002/smj.821

Adner, R., & Kapoor, R. (2016). Innovation ecosystems and the pace of substitution: Re-examining technology S-curves. *Strategic Management Journal, 37*(4), 625-648. doi:10.1002/smj.2363

Adner, R. O. N., & Kapoor, R. (2010). Value Creation In Innovation Ecosystems: How The Structure Of Technological Interdependence Affects Firm Performance In New Technology Generations. *Strategic Management Journal, 31*(3), 306-333.

Ahuja, G. (2000). The Duality of Collaboration: Inducements and Opportunities in the Formation of Interfirm Linkages. *Strategic Management Journal, 21*(3), 317-343. doi:10.1002/(SICI)1097-0266(200003)21:3<317::AID-SMJ90>3.0.CO;2-B

Aktinson, P., & Hammersley, M. (1998). Ethnography and participant observation. *Strategies of Qualitative Inquiry. Thousand Oaks: Sage*, 248-261.

Allee, V. (2000). Reconfiguring the value network. *Journal of Business strategy, 21*(4), 36-39.

Altman, E. J., Nagle, F., & Tushman, M. L. (2021). The Translucent Hand of Managed Ecosystems: Engaging Communities for Value Creation and Capture. *Academy of Management Annals*(ja).

Alvesson, M., & Kärreman, D. (2007). Constructing mystery: Empirical matters in theory development. *Academy of Management Review, 32*(4), 1265-1281. doi:10.5465/amr.2007.26586822

Anand, B. N., & Khanna, T. (2000). Do firms learn to create value? The case of alliances. *21*(3), 295-315. doi:doi:10.1002/(SICI)1097-0266(200003)21:3<295::AID-SMJ91>3.0.CO;2-O

Anderson, K. (2009). Ethnographic research: A key to strategy. *Harvard business review, 87*(3), 24.

Anderson, P., & Tushman, M. L. (1990). Technological Discontinuities and Dominant Designs: A Cyclical Model of Technological Change. *Administrative Science Quarterly, 35*(4), 604-633.

Argyres, N., & Bigelow, L. (2010). Innovation, Modularity, and Vertical Deintegration: Evidence from the Early U.S. Auto Industry. *Organization Science, 21*(4), 842-853. doi:10.1287/orsc.1090.0493

Assink, M. (2006). Inhibitors of disruptive innovation capability: a conceptual model. *European Journal of Innovation Management, 9*(2), 215-233. doi:10.1108/14601060610663587

Atuahene-Gima, K. (1993). Determinants of inward technology licensing intentions: An empirical analysis of Australian engineering firms. *Journal of Product Innovation Management, 10*(3), 230-240. doi:https://doi.org/10.1016/0737-6782(93)90028-O

Autio, E., Thomas, L., & Gann, D. (2016). Ecosystem value co-creation. *Innovation & Entrepreneurship Department Working Papers; Imperial College Business School: London, UK.*

Baldwin, C. Y.; Clark, Kim B.(1997);" Managing in an age of modularity. *Harvard business review*, 84-93.

Baldwin, C. Y., & Woodard, C. J. The Architecture of Platforms: A Unified View.(2009). *Platforms, Markets and Innovation*, 19-44.

Bamberger, P. A. (2018). AMD—Clarifying What We Are about and Where We Are Going. *Academy of Management Discoveries, 4*(1), 1-10. doi:10.5465/amd.2018.0003

Barney, J. B. (2001). Resource-based theories of competitive advantage: A ten-year retrospective on the resource-based view. *Journal of Management, 27*(6), 643-650. doi:doi:10.1177/014920630102700602

Basole, R. C. (2009). Visualization of interfirm relations in a converging mobile ecosystem. *Journal of information Technology, 24*(2), 144-159.

Bergek, A., Berggren, C., Magnusson, T., Hobday, M., Linköpings, u., Tekniska, h., . . . Institutionen för ekonomisk och industriell, u. (2013). Technological discontinuities and the challenge for incumbent firms: Destruction, disruption or creative accumulation? *Research Policy, 42*(6-7), 1210-1224. doi:10.1016/j.respol.2013.02.009

Bouncken, R. B., Fredrich, V., Ritala, P., & Kraus, S. (2020). Value-creation-capture-equilibrium in new product development alliances: A matter of coopetition, expert power, and alliance importance. *Industrial Marketing Management, 90*, 648-662. doi:https://doi.org/10.1016/j.indmarman.2020.03.019

Bowman, C., & Ambrosini, V. (2000). Value Creation Versus Value Capture: Towards a Coherent Definition of Value in Strategy. *British Journal of Management, 11*(1), 1-15. doi:https://doi.org/10.1111/1467-8551.00147

BREUER, H., & LÜDEKE-FREUND, F. (2017). VALUES-BASED NETWORK AND BUSINESS MODEL INNOVATION. *International Journal of Innovation Management, 21*(03), 1750028. doi:10.1142/s1363919617500281

Brusoni, S. (2013). The Organization of Innovation in Ecosystems: Problem Framing, Problem Solving, and Patterns of Coupling. In A. Prencipe (Ed.), *Collaboration and Competition in Business Ecosystems* (Vol. 30, pp. 167-194): Emerald Group Publishing Limited.

Brusoni, S., & Prencipe, A. (2013). The Organization Of Innovation In Ecosystems: Problem Framing, Problem Solving, And Patterns Of Coupling. In (Vol. 30, Pp. 167-194). *Bingley: Emerald Group Publishing Ltd.*

Ceccagnoli, M., Forman, C., Huang, P., & Wu, D. J. (2012). Cocreation of Value in a Platform Ecosystem! The Case of Enterprise Software. *MIS Quarterly, 36*(1), 263-290.

Cennamo, C. (2021). Competing in Digital Markets: A Platform-Based Perspective. *Academy of Management Perspectives, 35*(2), 265-291. doi:10.5465/amp.2016.0048

Christensen, C. M., & Rosenbloom, R. S. (1995). Explaining the attacker's advantage: Technological paradigms, organizational dynamics, and the value network. *Research Policy, 24*(2), 233-257. doi:http://dx.doi.org/10.1016/0048-7333(93)00764-K

Clarysse, B., Wright, M., Bruneel, J., & Mahajan, A. (2014). Creating value in ecosystems: Crossing the chasm between knowledge and business ecosystems. *Research Policy, 43*(7), 1164-1176. doi:http://dx.doi.org/10.1016/j.respol.2014.04.014

Cooke, P., Gomez Uranga, M., & Etxebarria, G. (1997). Regional innovation systems: Institutional and organisational dimensions. *Research Policy, 26*(4-5), 475-491.

Corso, M., & Pellegrini, L. (2007). Continuous and Discontinuous Innovation: Overcoming the Innovator Dilemma. *Creativity and Innovation Management, 16*(4), 333-347. doi:10.1111/j.1467-8691.2007.00459.x

Crossan, M. M., & Apaydin, M. (2010). A Multi-Dimensional Framework of Organizational Innovation: A Systematic Review of the Literature. *Journal of Management Studies, 47*(6), 1154-1191. doi:10.1111/j.1467-6486.2009.00880.x

Cunliffe, A. L. (2016). Republication of "On becoming a critically reflexive practitioner". *Journal of management education*, *40*(6), 747-768.

Cusumano, M. A., & Gawer, A. (2002). The elements of platform leadership. *MIT Sloan Management Review, 43*(3), 51.

Dattée, B., Alexy, O., & Autio, E. (2018). Maneuvering in poor visibility: How firms play the ecosystem game when uncertainty is high. *ACADEMY OF MANAGEMENT JOURNAL, 61*(2), 466-498.

Davis, J. P., & Eisenhardt, K. M. (2011). Rotating Leadership and Collaborative Innovation:Recombination Processes in Symbiotic Relationships. *56*(2), 159-201. doi:10.1177/0001839211428131

de Vasconcelos Gomes, L. A., Facin, A. F. F., & Salerno, M. S. (2021). Managing uncertainty propagation in innovation ecosystems. *TECHNOLOGICAL FORECASTING AND SOCIAL CHANGE, 171*, 120945.

Dedehayir, O., Mäkinen, S. J., & Ortt, J. R. (2018). Roles during innovation ecosystem genesis: A literature review. *Technological Forecasting And Social Change, 136*, 18-29.

Dedehayir, O., & Seppänen, M. (2015). Birth and expansion of innovation ecosystems: A case study of copper production. *Journal of technology management & innovation, 10*(2), 145-154.

Dhanaraj, C., & Parkhe, A. (2006). Orchestrating Innovation Networks. *Academy of Management Review, 31*(3), 659-669. doi:10.5465/amr.2006.21318923

Donada, C. (2018). Leadership in the electromobility ecosystem: integrators and coordinators. *International Journal of Automotive Technology and Management, 18*(3), 229-246. doi:10.1504/ijatm.2018.093417

Dubois, A., & Gadde, L.-E. (2002). Systematic combining: an abductive approach to case research. *Journal of Business Research, 55*(7), 553-560. doi:10.1016/S0148-2963(00)00195-8

Durst, S., & Poutanen, P. (2013). Success factors of innovation ecosystems-Initial insights from a literature review. *Pros. Co-Create*.

Easterby-Smith, M., Thorpe, R., & Jackson, P. R. (2012). *Management research*: Sage.

Eisenhardt, K. M. (1989). Building Theories from Case Study Research. *The Academy of Management Review, 14*(4), 532-550. doi:10.5465/AMR.1989.4308385

Engler, J., & Kusiak, A. (2011). Modeling an innovation ecosystem with adaptive agents. *International Journal of Innovation Science, 3*(2), 55-68.

Flick, U. (Ed.). (2013). *The SAGE handbook of qualitative data analysis*. Sage.

Furr, N., & Shipilov, A. (2018). Building the right ecosystem for innovation. *MIT Sloan Management Review, 59*(4), 59-64.

Galunic, D. C., & Eisenhardt, K. M. (1996). The Evolution of Intracorporate Domains: Divisional Charter Losses in High-Technology, Multidivisional Corporations. *Organization Science, 7*(3), 255-282. doi:10.1287/orsc.7.3.255

Galunic, D. C., & Eisenhardt, K. m. (2001). Architectural Innovation and Modular Corporation Forms. *Academy Of Management Journal, 44*(6), 1229.

Gawer, A. (2014). Bridging differing perspectives on technological platforms: Toward an integrative framework. *Research Policy, 43*(7), 1239-1249. doi:10.1016/j.respol.2014.03.006

Gawer, A., & Cusumano, M. A. (2008). How companies become platform leaders. *MIT Sloan Management Review, 49*(2), 28-35.

Gawer, A., & Cusumano, M. A. (2014). Industry Platforms and Ecosystem Innovation. *Journal of Product Innovation Management, 31*(3), 417-433. doi:10.1111/jpim.12105

Gawer, A., Cusumano, M. A. (2002). *Platform Leadership: How Intel, Microsoft and Cisco Drive Industry Innovation*. Boston;Jackson;: Harvard Business School Press.

Gehman, J., Glaser, V. L., Eisenhardt, K. M., Gioia, D., Langley, A., & Corley, K. G. (2017). Finding Theory–Method Fit: A Comparison of Three Qualitative Approaches to Theory Building. *Journal of Management Inquiry, 27*(3), 284-300. doi:10.1177/1056492617706029

Gioia, D. A., Corley, K. G., & Hamilton, A. L. (2013). Seeking qualitative rigor in inductive research: Notes on the Gioia methodology. *Organizational research methods*, *16*(1), 15-31.

Gobble, M. M. (2014). Charting the innovation ecosystem. *Research-Technology Management, 57*(4), 55-59.

Golafshani, N. (2003). Understanding reliability and validity in qualitative research. *The qualitative report, 8*(4), 597-606.

Gomes, L. A. d. V., Facin, A. L. F., Salerno, M. S., & Ikenami, R. K. (2018). Unpacking the innovation ecosystem construct: Evolution, gaps and trends. *Technological Forecasting And Social Change, 136*, 30-48. doi:https://doi.org/10.1016/j.techfore.2016.11.009

Granstrand, O., & Holgersson, M. (2020). Innovation ecosystems: A conceptual review and a new definition. *Technovation, 90-91*, 102098. doi:https://doi.org/10.1016/j.technovation.2019.102098

Guba, E. G., & Lincoln, Y. S. (1982). Epistemological and methodological bases of naturalistic inquiry. *ECTJ, 30*(4), 233-252.

Guba, E. G., & Lincoln, Y. S. (1994). Competing paradigms in qualitative research. *Handbook of qualitative research, 2*(163-194), 105.

Hannah, D. P., & Eisenhardt, K. M. (2018). How firms navigate cooperation and competition in nascent ecosystems. *Strategic Management Journal, 39*(12), 3163-3192. doi:10.1002/smj.2750

Henderson, R. M., & Clark, K. B. (1990). Architectural Innovation: The Reconfiguration of Existing Product Technologies and the Failure of Established Firms. *Administrative Science Quarterly, 35*(1), 9-30. doi:10.2307/2393549

Hodapp, D., Hawlitschek, F., & Kramer, D. (2019). *Value Co-Creation in Nascent Platform Ecosystems: A Delphi Study in the Context of the Internet of Things.* Paper presented at the ICIS.

Holgersson, M., Granstrand, O., & Bogers, M. (2018). The evolution of intellectual property strategy in innovation ecosystems: Uncovering complementary and substitute appropriability regimes. *Long Range Planning, 51*(2), 303-319. doi:https://doi.org/10.1016/j.lrp.2017.08.007

Iansiti, M., & Levien, R. (2004a). *The keystone advantage: what the new dynamics of business ecosystems mean for strategy, innovation, and sustainability*: Harvard Business Press.

Iansiti, M., & Levien, R. (2004b). Strategy as ecology. *Harvard business review, 82*(3), 68-81.

Ili, S., Albers, A., & Miller, S. (2010). Open innovation in the automotive industry. *R&D Management, 40*(3), 246-255. doi:10.1111/j.1467-9310.2010.00595.x

Jacobides, M. G., Cennamo, C., & Gawer, A. (2018). Towards a theory of ecosystems. *Strategic Management Journal, 39*(8), 2255-2276. doi:10.1002/smj.2904

Jacobides, M. G., MacDuffie, J. P., & Tae, C. J. (2016). Agency, structure, and the dominance of OEMs: Change and stability in the automotive sector. *Strategic Management Journal, 37*(9), 1942-1967. doi:10.1002/smj.2426

Kapoor, R. (2018). Ecosystems: broadening the locus of value creation. *Journal of Organization Design, 7*(1), 12. doi:10.1186/s41469-018-0035-4

Klepper, S. (2002). The capabilities of new firms and the evolution of the US automobile industry. *Industrial and Corporate Change, 11*(4), 645-666. doi:10.1093/icc/11.4.645

Lambe, C. J., & Spekman, R. E. (1997). Alliances, External Technology Acquisition, and Discontinuous Technological Change. *14*(2), 102-116. doi:doi:10.1111/1540-5885.1420102

Lange, K., Müller-Seitz, G., Sydow, J., & Windeler, A. (2013). Financing innovations in uncertain networks—Filling in roadmap gaps in the semiconductor industry. *Research Policy, 42*(3), 647-661. doi:https://doi.org/10.1016/j.respol.2012.12.001

Langley, A. (1999). Strategies for Theorizing from Process Data. *Academy of Management Review, 24*(4), 691-710. doi:10.5465/amr.1999.2553248

Lee, E.-K., Gerla, M., Pau, G., Lee, U., & Lim, J.-H. (2016). Internet of Vehicles: From intelligent grid to autonomous cars and vehicular fogs. *International Journal of Distributed Sensor Networks, 12*(9). doi:10.1177/1550147716665500

Lee, S.-H., Peng, M. W., & Barney, J. B. (2007). Bankruptcy Law and Entrepreneurship Development: A Real Options Perspective. *Academy of Management Review, 32*(1), 257-272. doi:10.5465/amr.2007.23464070

Lepak, D. P., Smith, K. G., & Taylor, M. S. (2007). Value Creation and Value Capture: A Multilevel Perspective. *Academy of Management Review, 32*(1), 180-194. doi:10.5465/amr.2007.23464011

Li, Y.-R. (2009). The technological roadmap of Cisco's business ecosystem. *TECHNOVATION, 29*(5), 379-386. doi:https://doi.org/10.1016/j.technovation.2009.01.007

Linden, G., Kraemer, K. L., & Dedrick, J. (2009). Who captures value in a global innovation network?: the case of Apple's iPod. *Commun. ACM, 52*(3), 140-144. doi:10.1145/1467247.1467280

Lundvall, B.-A. (1992). National innovation system: towards a theory of innovation and interactive learning. *Pinter, London.*

Lundvall, B.-Å. (1992). User-producer relationships, national systems of innovation and internationalisation. In *National systems of innovation: Towards a theory of innovation and interactive learning* (pp. 45-67): Frances Pinter Publishers Ltd.

Lundvall, B. Å. (2007). National Innovation Systems—Analytical Concept and Development Tool. *Industry and Innovation, 14*(1), 95-119. doi:10.1080/13662710601130863

Magnusson, M., & Pasche, M. (2014). A contingency-based approach to the use of product platforms and modules in new product development. *Journal of Product Innovation Management, 31*(3), 434-450.

Mason, M. (2010, August). Sample size and saturation in PhD studies using qualitative interviews. In *Forum qualitative Sozialforschung/Forum: qualitative social research* (Vol. 11, No. 3).

Mäkinen, S. J., & Dedehayir, O. (2012, 18-20 June 2012). *Business ecosystem evolution and strategic considerations: A literature review.* Paper presented at the 2012 18th International ICE Conference on Engineering, Technology and Innovation.

McIntyre, D. P., & Srinivasan, A. (2017). Networks, platforms, and strategy: Emerging views and next steps. *Strategic Management Journal, 38*(1), 141-160. doi:10.1002/smj.2596

Mercan, B., & Goktas, D. (2011). Components of innovation ecosystems: a cross-country study. *International Research Journal of Finance and Economics, 76*(16), 102-112.

Miles, M. B., & Huberman, A. M. (1994). *Qualitative data analysis: An expanded sourcebook*: sage.

Möller, K., & Rajala, A. (2007). Rise of strategic nets — New modes of value creation. *Industrial Marketing Management, 36*(7), 895-908. doi:https://doi.org/10.1016/j.indmarman.2007.05.016

Mondragon, C. E. C., Mondragon, A. E. C., & Miller, R. (2007). Modularity, open architecture and innovation: an automotive perspective. *International Journal of Automotive Technology and Management, 6*(3), 346-363. doi:10.1504/IJATM.2006.012125

Moore, J. F. (1993). Predators and prey: a new ecology of competition. *Harvard business review, 71*(3), 75-83.

Nelson, R. R., & Sidney, G. (2005). Winter. 1982. An evolutionary theory of economic change. In: Cambridge, MA: Harvard University Press.

Nikitas, A., Njoya, E. T., & Dani, S. (2019). Examining the myths of connected and autonomous vehicles: analysing the pathway to a driverless mobility paradigm. *International Journal of Automotive Technology and Management, 19*(1-2), 10-30.

Normann, R., & Ramírez, R. (1993). From value chain to value constellation: designing interactive strategy. *Harvard business review, 71*(4), 65-77.

Oh, D. S., Phillips, F., Park, S., & Lee, E. (2016). Innovation ecosystems: A critical examination. *Technovation, 54*, 1-6. doi:10.1016/j.technovation.2016.02.004

Pankov, S., Velamuri, V. K., & Schneckenberg, D. (2021). Towards sustainable entrepreneurial ecosystems: examining the effect of contextual factors on sustainable entrepreneurial activities in the sharing economy. *Small Business Economics, 56*(3), 1073-1095. doi:10.1007/s11187-019-00255-5

Peltoniemi, M. (2004). *Cluster, value network and business ecosystem: Knowledge and innovation approach.* Paper presented at the Organisations, Innovation and Complexity: New Perspectives on the Knowledge Economy" conference, September.

Peppard, J., & Rylander, A. (2006). From Value Chain to Value Network. *European Management Journal, 24*(2), 128-141. doi:http://dx.doi.org/10.1016/j.emj.2006.03.003

Perks, H., & Roberts, D. (2013). A Review of Longitudinal Research in the Product Innovation Field, with Discussion of Utility and Conduct of Sequence Analysis. *Journal of Product Innovation Management, 30*(6), 1099-1111. doi:10.1111/jpim.12048

Persson, M., & Åhlström, P. (2013). Product modularisation and organisational coordination. *International Journal of Automotive Technology and Management, 13*(1), 55-74.

Pinch, T. J., & Bijker, W. E. (1987). The social construction of facts and artifacts: Or how the sociology of. *The social construction of technological systems: New directions in the sociology and history of technology, 17*.

Poblete, L., Kadefors, A., Kohn Rådberg, K., & Gluch, P. (2022). Temporality, temporariness and keystone actor capabilities in innovation ecosystems. *Industrial Marketing Management, 102*, 301-310. doi:https://doi.org/10.1016/j.indmarman.2022.01.012

Popper, K. (2005). *The logic of scientific discovery*: Routledge.

Porter, M. E. (1980). Competitive strategy: Techniques for analyzing industries and competition. *New York, 300*.

Reeves, M., Lotan, H., Legrand, J., & Jacobides, M. G. (2019). How business ecosystems rise (and often fall). *MIT Sloan Management Review, 60*(4), 1-6.

Reid, S. E., & De Brentani, U. (2004). The Fuzzy Front End of New Product Development for Discontinuous Innovations: A Theoretical Model. *Journal of Product Innovation Management, 21*(3), 170-184. doi:10.1111/j.0737-6782.2004.00068.x

REMNELAND-WIKHAMN, B., LJUNGBERG, J., BERGQUIST, M., & KUSCHEL, J. (2011). OPEN INNOVATION, GENERATIVITY AND THE SUPPLIER AS PEER: THE CASE OF IPHONE AND ANDROID. *International Journal of Innovation Management, 15*(01), 205-230. doi:10.1142/s1363919611003131

Rietveld, J., Schilling, M. A., & Bellavitis, C. (2019). Platform Strategy: Managing Ecosystem Value Through Selective Promotion of Complements. *Organization Science, 30*(6), 1232-1251. doi:10.1287/orsc.2019.1290

Ritala, P., & Almpanopoulou, A. (2017). In defense of 'eco' in innovation ecosystem. *TECHNOVATION, 60-61*, 39-42. doi:https://doi.org/10.1016/j.technovation.2017.01.004

Ritala, P., Husted, K., Olander, H., & Michailova, S. (2018). External knowledge sharing and radical innovation: the downsides of uncontrolled openness. *Journal of knowledge management, 22*(5), 1104-1123. doi:10.1108/JKM-05-2017-0172

Roecker, J., Mocker, M., & Novales, A. (2017). Digitized products: Challenges and practices from the creative industries.

Rohrbeck, R., Hölzle, K., & Gemünden, H. G. (2009). Opening up for competitive advantage – How Deutsche Telekom creates an open innovation ecosystem. *R&D Management, 39*(4), 420-430. doi:10.1111/j.1467-9310.2009.00568.x

Russell, M. G., & Smorodinskaya, N. V. (2018). Leveraging complexity for ecosystemic innovation. *TECHNOLOGICAL FORECASTING AND SOCIAL CHANGE, 136*, 114-131. doi:https://doi.org/10.1016/j.techfore.2017.11.024

Saarijärvi, H., Kannan, P. K., & Kuusela, H. (2013). Value co-creation: theoretical approaches and practical implications. *European Business Review, 25*(1), 6-19. doi:10.1108/09555341311287718

Sanchez, R., & Mahoney, J. T. (1996). Modularity, flexibility, and knowledge management in product and organization design. *Strategic Management Journal, 17*(S2), 63-76.

Scaringella, L., & Radziwon, A. (2018). Innovation, entrepreneurial, knowledge, and business ecosystems: Old wine in new bottles? *TECHNOLOGICAL FORECASTING AND SOCIAL CHANGE, 136*, 59-87.

Siggelkow, N. (2007). Persuasion with case studies. *ACADEMY OF MANAGEMENT JOURNAL, 50*(1), 20-24.

Teece, D. J. (2007). Explicating dynamic capabilities: the nature and microfoundations of (sustainable) enterprise performance. *Strategic Management Journal, 28*(13), 1319-1350.

Teece, D. J., Pisano, G., & Shuen, A. (1997). Dynamic Capabilities and Strategic Management. *Strategic Management Journal, 18*(7), 509-533. doi:10.1002/(SICI)1097-0266(199708)18:7<509::AID-SMJ882>3.0.CO;2-Z

Thomas, L., & Autio, E. (2013). *Emergent equifinality: an empirical analysis of ecosystem creation processes.* Paper presented at the Proceedings of the 35th DRUID Celebration Conference, Barcelona, Spain.

Thomas, L. D., & Autio, E. (2018). *Ecosystem value potential: An organizational field perspective.* Paper presented at the Academy of Management Proceedings.

Thomas, L. D., & Autio, E. (2019). Innovation ecosystems. *Available at SSRN 3476925.*

Thomas, L. D. W., Autio, E., & Gann, D. M. (2014). ARCHITECTURAL LEVERAGE: PUTTING PLATFORMS IN CONTEXT. *Academy of Management Perspectives, 28*(2), 198-219. doi:10.5465/amp.2011.0105

Thomas, L. D. W., Autio, E., & Gann, D. M. (2022). Processes of ecosystem emergence. *TECHNOVATION, 115*, 102441. doi:https://doi.org/10.1016/j.technovation.2021.102441

Tiwana, A. (2015). Evolutionary Competition in Platform Ecosystems. *26*(2), 266-281. doi:10.1287/isre.2015.0573

Tiwana, A., Konsynski, B., & Bush, A. A. (2010). Research Commentary—Platform Evolution: Coevolution of Platform Architecture, Governance, and Environmental Dynamics. *Information Systems Research, 21*(4), 675-687. doi:10.1287/isre.1100.0323

Tripsas, M. (1997). Unraveling the Process of Creative Destruction: Complementary Assets and Incumbent Survival in the Typesetter Industry. *Strategic Management Journal, 18*(S1), 119-142. doi:10.1002/(SICI)1097-0266(199707)18:1+<119::AID-SMJ921>3.3.CO;2-S

Ucbasaran, D., Shepherd, D. A., Lockett, A., & Lyon, S. J. (2013). Life after business failure: The process and consequences of business failure for entrepreneurs. *Journal of Management, 39*(1), 163-202.

Utterback, J. (2004). The dynamics of innovation. *Educause review, 39*, 42-51.

Utterback, J. M. (1994). *Mastering the dynamics of innovation: how companies can seize opportunities in the face of technological change*. Boston, Mass: Harvard Business School Press.

Valkokari, K., Seppänen, M., Mäntylä, M., & Jylhä-Ollila, S. (2017). Orchestrating innovation ecosystems: A qualitative analysis of ecosystem positioning strategies.

Van de Ven, A. H., & Huber, G. P. (1990). Longitudinal field research methods for studying processes of organizational change. *Organization Science, 1*(3), 213-219.

van der Borgh, M., Cloodt, M., & Romme, A. G. L. (2012). Value creation by knowledge-based ecosystems: evidence from a field study. *R&D Management, 42*(2), 150-169. doi:https://doi.org/10.1111/j.1467-9310.2011.00673.x

Visscher, K., Hahn, K., & Konrad, K. (2021). Innovation ecosystem strategies of industrial firms: A multilayered approach to alignment and strategic positioning. *Creativity and Innovation Management, 30*(3), 619-631. doi:https://doi.org/10.1111/caim.12429

Williamson, P. J., & De Meyer, A. (2012a). Ecosystem Advantage: How to Successfully Harness the Power of Partners. *55*(1), 24-46. doi:10.1525/cmr.2012.55.1.24

Williamson, P. J., & De Meyer, A. (2012b). Ecosystem Advantage: How to Successfully Harness the Power of Partners. *California Management Review, 55*(1), 24-46. doi:10.1525/cmr.2012.55.1.24

Wulf, A., & Butel, L. (2017). Knowledge sharing and collaborative relationships in business ecosystems and networks: A definition and a demarcation. *Industrial Management & Data Systems, 117*(7), 1407-1425.

Yang, S. H., Nam, C., & Kim, S. (2018). The effects of M&As within the mobile ecosystem on the rival's shareholder value: The case of Google and Apple. *Telecommunications Policy, 42*(1), 15-23.

Yin, R. K. (2009). *Case study research: design and methods* (Vol. 5). London: SAGE.

Yoo, Y., Henfridsson, O., & Lyytinen, K. (2010). Research Commentary—The New Organizing Logic of Digital Innovation: An Agenda for Information Systems Research. *Information Systems Research, 21*(4), 724-735. doi:10.1287/isre.1100.0322

Yoo, Y., Richard J. Boland, J., Lyytinen, K., & Majchrzak, A. (2012). Organizing for Innovation in the Digitized World. *Organization Science, 23*(5), 1398-1408. doi:10.1287/orsc.1120.0771

Zahra, S. A., & Nambisan, S. (2012). Entrepreneurship and strategic thinking in business ecosystems. *Business Horizons, 55*(3), 219-229. doi:https://doi.org/10.1016/j.bushor.2011.12.004

Zhang, J., & Liang, X.-J. (2011). Business ecosystem strategies of mobile network operators in the 3G era: The case of China Mobile. *Telecommunications Policy, 35*(2), 156-171. doi:https://doi.org/10.1016/j.telpol.2010.12.009

Zhang, Y., Li, H., Hitt, M. A., & Cui, G. (2007). R&D Intensity and International Joint Venture Performance in an Emerging Market: Moderating Effects of Market Focus and Ownership Structure. *Journal of international business studies, 38*(6), 944-960. doi:10.1057/palgrave.jibs.8400301