THESIS FOR THE DEGREE OF LICENTIATE OF ENGINEERING

The emergence of innovation ecosystems: Exploring the role of the keystone firm

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Abstract

During periods of technological change, firms seek new collaborations and sometimes even reach out to competitors in order to obtain new resources and competences. Understanding the collaborations surrounding new technologies has implications for firms pursuing opportunities with new technologies. The notion of ecosystems is increasingly used in literature to address value creation activities involving a network of firms. The purpose of this licentiate thesis is to understand the emergence of new innovation ecosystems. Previous research on ecosystems recognizes "keystone" firm as the anchor that ensures growth and stability in the ecosystem. However, the activities that foreshadow the development of an ecosystem and the role played by a prospective keystone firm in the emergence of an ecosystem is undertheorized.

Based on a longitudinal case study of a technology development program at an automotive firm, the findings presented in this licentiate thesis show how the joint venture established by the incumbent firm led to the development of a modular technology. The main findings illustrate how the incumbent automotive firm attracted a network of actors that develop innovative solutions and other complementarities for the technology. The network of actors developing offerings for the modular technology, in turn, facilitated the incumbent firm to position itself as a keystone firm and orchestrate the emergence of a new innovation ecosystem. The thesis contributes to theory by showing how a firm can orchestrate the emergence of an innovation ecosystem and position itself as the keystone firm.

Keywords: Technology, innovation, ecosystem, dominant design, autonomous cars

List of appended papers

Paper I

Pushpananthan G. and Elmquist M., Lindlöf L. (2018). The transformation of the automotive firm in the age of automation. *EURAM conference, June 19-22, 2018, Reykjavik, Iceland*.

Paper II

Söderqvist J.B. and Pushpananthan G. (2019). The blind leading the mute: Formal leaders' potential to facilitate institutionalization of the agile myth. *EURAM conference, June 26-28, 2019, Lisbon, Portugal.*

Paper III

Pushpananthan G., Lindlöf L. and Rothoff M. (2019). Role of tactics in R&D projects. *R&D Management conference, June 17 -21, 2019, Paris, France.*

Paper IV

Pushpananthan G., Elmquist M. (2019) From a joint venture to an innovation ecosystem: Lessons from a longitudinal study of an autonomous car project. *Manuscript submitted to an international journal.*

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1. INTRODUCTION

1.1. SETTING THE SCENE

Over the past decade, technology has advanced at a rapid pace resulting in automation and digitalization of industries. This dynamic environment, characterized by fast changes in technology, has created a need to revisit established theories on value creation and explore how firms in today's digital economy establish competitive advantage during times of technological change. The most habitual question in strategy and management literature has been about how firms compete when new technologies emerge? Some technologies immediately substitute the existing technology while others may take decades to become mainstream. The pace of substitution, depending on various factors, differs greatly (Anderson *et al.*, 1990). A number of seminal works have shown that new technologies alter the competitive landscape, leading to the entry of new firms in an industry (Schumpeter, 1942; Teece *et al.*, 1997). When new technologies and competition enter an industry, established firms (incumbents) struggle to survive which often lead to waves of creative destruction in the market (Adner *et al.*, 2016; Schumpeter, 1942; Tripsas, 1997) (e.g., Kodak disrupted by digital photography; (Vecchiato, 2017)). Interestingly, during such technology shifts, some incumbents survive and prosper whilst others fail (Tripsas, 1997). Amongst the survivors, few are quick to leverage the new technology to regain leadership position whist others take years or decades to gain dominance in the new technology (e.g., Apple gaining leadership in smartphone and PC industry from the verge of bankruptcy). Thus, incumbent firms have both succeeded and failed during times of technological change. In literature, technology is often cited to be a major reason for the success and failure of firms. Whilst a shift in the technological landscape often leads to shake-outs in an industry, the reason for incumbents' failure is much broader than just the technology per se. The lack of foresight, unwillingness to share profits, path dependence etc. have been attributed as reasons for the failure of incumbents (e.g., (Anderson *et al.*, 1990; Suárez *et al.*, 1995; Teece *et al.*, 1997; Tripsas, 1997; Utterback, 1994).

Today, digital technology is altering the basic tenets of value creation as customers increasingly seek not just stand-alone products but also services that cater to their preferences. Internet and Communication technology (ICT) has broken down the barriers to compete as start-ups challenge industry leaders with radical innovation. This is evident at the success of multinationals – yesteryear start-ups – such as Amazon, Facebook, Tencent, Uber who dominate their respective industries and sometimes even carve out new industries. The establishment of new or hybrid industries is a result of the convergence of technologies in products and services. For example, combining digital technology and taxi business has resulted in ride sharing firms identified as belonging to both technology and transportation industries (e.g., Uber, Lyft, Grab, BlaBlaCar etc.). Further, digital technology has broken down the traditional industry barriers as products and services are increasingly created by an amalgamation of firms from different industries working together. Such inter-firm collaborations transgressing industry boundary(ies) and traditional value chain hierarchies are often addressed as *ecosystems* (Gawer *et al.*, 2002; Linden *et al.*, 2009). This is partly due to the non-hierarchical nature of value creation activities, organic development of mutually beneficial partnerships akin to biological ecosystems, and the interactions between firms with completely unrelated business areas (e.g., Amazon acquiring grocery store chain Whole Foods; Apple launching credit card service in partnership with Goldman Sachs). In line with this trend, Adner *et al.* (2016, p.626) argue that understanding technology transitions and the pace of substitution necessitates the "examination of interdependencies in the broader ecosystem of components and complements in which the focal technologies are embedded". However, investigations on such ecosystems have not addressed the question on how ecosystems emerge, partly due the ex-post definition of the term ecosystem (Gawer *et al.*, 2014; Jacobides *et al.*, 2018).

1.2. PROBLEM AREA

In a constantly changing environment characterized by rapid advances in technology, firms actively seek new resources and competences to create value. Organizational studies discuss how firms create value by using new technologies, new materials and methods to deliver new products and services (Clarysse *et al.*, 2014). Value chain thinking suggests an ordered sequence of activities and has been useful to understand the functioning of traditional industries churning out physical products (Allee, 2000). It has also been useful in explaining the linkage of activities within an industry (Peppard *et al.*, 2006).

However, the value chain concept is becoming redundant due to the digitalization of products and services (Peppard *et al.*, 2006). Instead, the notion of "value networks" is gaining importance as it presents multidimensional linkages between actors who combine their skills and assets to create value (Adner *et al.*, 2010; Clarysse *et al.*, 2014; Galunic *et al.*, 2001). Previous literature on organizational capability has mainly focused on the internal organization perspective, but less on how firms can manage and organize their innovation processes by collaborating with other actors in a network. The article by Moore (1993) on "business ecosystems" was the starting point for a number of articles using the analogy of biological ecosystem to conceptualize value capture in a network. In this context, it is especially interesting to examine how (and when) ecosystems emerge during a period of technology transition in an industry.

During periods of technological change, firms seek new collaborations and sometimes even reach out to competitors in order to obtain new resources and competences (Furr *et al.*, 2018). Also, the existence of interdependencies between innovations has been well documented in literature (Adner *et al.*, 2016). Further, literature on ecosystem recognizes "keystone" firm as the anchor that ensure growth and stability in the ecosystem. However, the activities that foreshadow the development of an ecosystem and the role played by the prospective keystone firm in the emergence of an ecosystem is undertheorized in literature (Jacobides *et al.*, 2018).

1.3. PURPOSE AND RESEARCH QUESTIONS

In order to contribute to literature on ecosystems, this research looks into the automotive industry wherein a technology transition (i.e., Autonomous Drive) has drastically altered the competitive advantage. **The purpose of this licentiate thesis is to understand how an incumbent firm orchestrates the emergence of an ecosystem and positions itself as a keystone firm.** The findings presented in this thesis are a result of a longitudinal case study of an Autonomous Drive (AD) technology development program at Volvo Car Group (Henceforth addressed as Volvo). Additionally, the study elucidates the implications of such collaborative endeavors from the perspective of an incumbent firm. By illustrating the collaborations set up by the incumbent firm (Volvo), the thesis shows the transition in Volvo's role from being an OEM in a traditional value chain to a keystone firm in an emerging innovation ecosystem.

The thesis will address the following research questions:

RQ1: How does a new ecosystem emerge?

RQ2: How does a keystone firm orchestrate collaborations in an emerging ecosystem ?

2. EMPIRICAL CONTEXT

The aim of the licentiate study is to better understand the impact of new technology on traditional industries. For this, the automotive industry was selected as appropriate to understand the impact of a new technology. The area of autonomous driving in particular, was identified as an appropriate empirical context to investigate the aforementioned research questions. In this chapter the developments of the industry will be summarized.

2.1. THE AUTOMOTIVE INDUSTRY

From carts and carriages pulled by animals to vehicles that drive themselves, the mode of transportation has seen massive transformations. Cars, in particular, have developed from being a luxury to being a basic necessity for most people. Yet, the evolution of the industry prior to the digital era is nothing compared to the rapid advancements taking place in the industry today. Recent trends in electrification, ride sharing and autonomous drive has drastically altered the competitive landscape of the industry (Lee *et al.*, 2016; Pelliccione *et al.*, 2017; Thomopoulos *et al.*, 2015).

Due to the increase in the amount of digital features in modern vehicles, competences and resources outside the OEMs' traditional value chain are critical (Bimbraw, 2015; Lee *et al.*, 2016; Mondragon *et al.*, 2007). This entails that cars are becoming complex product systems encompassing advanced software along with hardware (Burke *et al.*, 2004; Pelliccione *et al.*, 2017). The increase in the amount of embedded systems in modern vehicles coupled with advancement in internet and communication technology (ICT) has drastically shifted the innovation landscape (Mondragon *et al.*, 2007; Pretschner *et al.*, 2007; Townsend *et al.*, 2014). The automotive industry is now approaching the next major transformation: autonomous driving – propelled by an integrated interplay of both market and technology factors (Pinch *et al.*, 1987).

2.2. AUTONOMOUS DRIVE: WHAT IS IT?

The autonomous car (also known as a driverless car, a robotic car or a self-driving car) is a technological system that needs to sense the environment, detect the position of vehicle of the road, and make decisions on how to manoever the vehicle in a given situation (www.bosch.com). These vehicles rely on software to bridge the gap between sensor physics and the mechanical actuation of the vehicles (e.g., steering and brakes). The vehicle operates by using data from different sensors like radars, cameras and lidars which is then processed by algorithms to precisely compute the position, orientation etc. An autonomous car is thus a complex technological system combining multiple sub-systems that handle perception, decision making, and operation of the vehicle.

In the industry and in media, driverless technology is commonly addressed by many different terms, such as autonomous driving system, self-driving car technology, autonomous car technology, autonomous vehicles, etc. For consistency and clarity, this thesis will address this technological system as Autonomous Drive (AD) technology. Autonomous vehicles have the potential to transform the entire automotive industry and alter much of today's transport infrastructure (Greenblatt *et al.*, 2015; Lee *et al.*, 2016). Still, standardization and established domain design provide a hurdle for the adoption of AD technology (Abernathy *et al.*, 1978; Anderson *et al.*, 1990). New technologies need a standard or dominant design that allows for widespread adoption (Brem *et al.*, 2016). The AD technology is increasingly developed outside the OEM's value chain and the established firms need to interact with actors outside the industry to access necessary resources and competences.

To summarize, the setting of the development of the AD technology in the automotive industry is considered a suitable case to study emerging innovation ecosystems. It remains to be seen how these developments will evolve and if the incumbent automotive firms will retain their current dominance in the industry.

2.3. Volvo's AD program

Volvo Car Group is a Swedish car manufacturer that is considered one of the market leaders in the area of safety (Liu et al., 2004). In recent years, Volvo has expressed interest in developing AD and has invested hugely in its AD program[1] (VolvoCars, 2019). Volvo's strong safety and Advanced Driver Assistance Systems (ADAS) record makes development of AD technology a natural step for the firm. Due to the inherent complexity in developing autonomous cars, Volvo established several collaborations in the area of AD and the partners include many non-automotive firms. The main purpose of the AD program is to develop AD technology alongside the software and hardware systems required to produce a fully autonomous car. Volvo's AD program is based on three main sub-projects: the Drive Me project (a research initiative); Zenuity (a JV with Veoneer,) and the Uber project (redundant car platform). Drive Me involves several research platforms with various partner organizations (Victor *et al.*, 2017).

The software development is handled by Zenuity, a new entrant in the industry created as a joint venture between Volvo and Veoneer (previously a part of Autoliv) (VolvoCars, 2017a). Zenuity develops ADAS and AD software solutions for Volvo's AD program. Veoneer is a major automotive supplier with expertise in the area of automotive safety and production of seatbelts, airbags, collision avoidance systems, etc. Both Volvo and Veoneer have transferred their intellectual property on 'Advanced Driver Assistance Systems' (ADAS), know-how and personnel to the joint venture firm 'Zenuity' (VolvoCars, 2017a). Despite the shared ownership and assets, Zenuity is an independent firm and positions itself as an AD and ADAS software supplier (Zenuity, 2018). The AD and ADAS software solutions were developed in close collaboration with Volvo and are commercialized through Veoneer.

Volvo set up a collaboration with Uber, a global leader in the ridesharing business to develop base vehicles with latest technologies necessary for a fully autonomous cars (VolvoCars, 2016, 2017b). According to the CEO of Volvo, the Uber partnership is in line with Volvo's intention to be a supplier of AD ride-sharing services globally (VolvoCars, 2017b). The CEO believes

[1] AD program began as an internal project at Volvo. Later, it was reorganized into a program

that the alliance with Uber positions Volvo at the heart of the technological revolution taking place in the automotive industry (VolvoCars, 2016).

Apart from Volvo and Zenuity, several other actors such as Chalmers University, Autoliv, City of Gothenburg, Lindholmen Science Park etc. are involved in the Drive Me project. Thus, much of the innovation activity in developing autonomous drive technology is taking place outside of Volvo in a collaborative set up. The thesis is based upon research carried out at Volvo Car group. Findings pertaining to the AD program and references to Zenuity, Uber and other actors are based upon insights gained from the research carried out at Volvo's autonomous drive program.

3. THEORETICAL FRAMEWORK

This section contains a review of literature on innovation and ecosystem. The first part provides a general overview on technology and innovation in order to position the research context (i.e., technology transition in mature industries). This is followed by details regarding previous research on value networks and ecosystems where the thesis makes contributions.

3.1. TECHNOLOGICAL CHANGE AND INNOVATION

Innovation shapes the industries and determines the future of firms (J. M. Utterback, 1994) and is the most sought-after activity by firms in order to sustain their competitive advantage and technology is a key factor in innovation success. The knowledge economy and rapid advancements in technology has reiterated the urgency and need for innovation as it is central to firm competitiveness (Lawson *et al.*, 2001). Yet, very few large firms have been successful in carrying out innovation that are disruptive or radical in nature. Non-incremental innovation, the one that is considered to be quintessential for long term survival has been a conundrum for large firms as startups over the past decade have been successful at challenging large established firms in ways that have been never seen before (Latzer, 2009).

In today's competitive environment, leaders and managers are driving to build organizational capabilities to engage in innovative endeavors (Teece *et al.*, 1994). Large firms possess the resources and capabilities that are one of the greatest constraints for startups and small firms but there seems to be little evidence of positive relationship between R&D intensity and successful innovation (Klepper, 2002; Lee *et al.*, 2001; Tripsas, 1997). Interestingly, large firms' existing customer base makes them reluctant to undertake radical innovation that can cannibalize on existing customer bases and revenues (Govindarajan *et al.*, 2005; Tripsas, 1997). However, in today's digital world, the need to innovate – *not just occasional or incremental* – but systematic, continuous and radical innovation with a solid success rate is quintessential for survival (Lawson & Samson, 2001). Technological change underpins the innovation trajectory and serves as both creative and destructive force in the survival of firms (Utterback, 2004).

Explaining the dynamics of technological change is an important aspect of technology strategy literature (Adner *et al.*, 2016). The technology S-curve is an undisputed representation of both technology life cycle and competition between technologies (Adner *et al.*, 2016; Christensen *et al.*, 1995; Utterback, 1994). Contrary to previous knowledge that new technology becomes mainstream when it posits superior performance, Christensen *et al.* (1995) illustrated that technology transition can take place even when the performance of the new technology is inferior to the old. He argued that if established firms over-served on the main performance dimension, users who expect performance on other dimensions may embrace a new technology even if it is inferior (to existing technology) along the main performance dimension. Interestingly, (Adner *et al.*, 2016) points out that literature on technology strategy focus on the supply side (i.e., firms developing the technology) and diffusion of innovation literature on the demand side (i.e., user adopting a technology). A deeper understanding of technological change however demands a holistic understanding that links technology evolution and technology adoption. Technology is often packaged in a system or a product and consumers assess the performance of the entire system rather than independent technologies (Adner *et al.*, 2016). Thus, in order to create value, firms must focus not just on the performance of the focal technology but on the entire system. Adner *et al.* (2010) opine that firms strive to be first movers with new technologies in order to establish a competitive advantage. However, to be technology leaders and introduce new innovation, a firm needs support from other actors to develop interdependent innovations Adner *et al.* (2010).

3.2. The dominant design battle

Along with technology, markets play an equally important role, one good example is the QWERTY keyboard[2] standard which is indomitable due to its high market penetrations (David, 1985). The invasion of new technologies follows a predictable trajectory, through a process of variation, selection and retention(Nelson *et al.*, 2005; Pinch *et al.*, 1987). Initially, an established technology usually offers better performance (or lower cost or both) than an invading technology. However, if the invading technology has any merit, it rapidly develops and attains better performance than the established technology which by now has entered a stage of slow, incremental improvements (Christensen *et al.*, 1995; Utterback, 1994). Nevertheless, new technologies do not always obscure old technology and in certain cases, both technologies become stronger thereby rendering a symbiotic relationship (J. Utterback, 2004). For example, ‘shaving blades and electric razors’ or ‘DVDs and movies in theatres’, both remain successful and also complement each other (Utterback, 2004).

Technological discontinuity initiates an era of ferment leading to intense competition amongst the variations leading to the selection of a dominant configuration (Anderson *et al.*, 1990). During this phase, a dominant design is not yet established and marks the beginning of a new innovation S-curve. After intense competition, a dominant design is established by the early majority in order to overcome technical obstacles and facilitate commercialization. The established dominant design then becomes the standard architecture over which incremental improvements are made until another discontinuous technology leads to a new cycle of variation, selection and retention. The emergence of a dominant design paradigm signals the acceptance of agreed upon standards and these remain intact until overturned by a new design (Teece, 1986). For example, the wireless inductive charging technology for mobile devices had two technical designs, ‘PMA’ by Powermat Technologies and ‘Qi’ by Wireless Power Consortium (WPC). When the two leading mobile handset manufactures Apple and Samsung adopted Qi technology, it became the dominant design for inductive charging in the industry. Eventually, Powermat abandoned ‘PMA’ and joined together with WPC to promote the ‘Qi’ technology as the industry standard for wireless inductive charging. New technology thus initiates a period of intense competition and collaboration between firms in order to establish a dominant design. During this period, firms seek new ways to create value using the new technology.

[2] The survival of QWERTY keyboard is largely due to the “presence of strong technical interrelatedness, scale economics and irreversibilities due to learning and habituation” (David, 1985, p. 336).

3.3. VALUE CREATION IN NETWORKS

In a knowledge economy, the most pertinent question is perhaps to ask, how is value created? Normann *et al.* (1993) describe strategy as the art of creating value. Strategic activities involve the way in which a company links together its resources and competences to create value for its customers. Value chain thinking has been the most useful way to understand the value creation activities in traditional industries churning out physical products (Allee, 2000). The concept of value chain is useful to understand the linkage of activities within an industry (Peppard *et al.*, 2006). According to traditional models of industrial economy, every firm positions itself in a value chain with supplier providing inputs to firms downstream who then combine these inputs and pass it to next actors in the chain, either businesses or end customers (Normann *et al.*, 1993). In today's digital economy, however, the concept of value chain is becoming redundant due to the digitalization of products and services (Peppard & Rylander, 2006). The value chain approach presents little distinction between the actors in terms of their relationship with the focal firm (Adner *et al.*, 2010a). The importance of an actor with high bargaining power over a focal firm's ability to capture value do not change based on its position as a complementor, buyer or supplier. With advancements in internet and communication technologies (ICT), the physical dimension of the value chain is losing its relevance in modern industries. Thus, the traditional methods of analyzing competitive advantage (Porter, 1980), need to be revisited due to the emergence of the network economy.

In today's digital age, the creation of a superior product spreads beyond the boundaries of the lead firm (Linden *et al.*, 2009). The value chain approach suggests ordered sequence of activities whereas a network presents multidimensional linkages (Adner *et al.*, 2010; Peltoniemi, 2004). In a value network, value is created by a group of firms combining their skills and assets leading to the recombination of capabilities in the network (Clarysse *et al.*, 2014; Galunic *et al.*, 2001). The notion of networks is central to innovation and dates back to Schumpeter who argued that innovation arises from new combinations of ideas (Dodgson et al., 2013). An innovative idea starts out as a set of connections between neurons within the brain (Dodgson *et al.*, 2013) and a network of interconnected ideas manifesting into an innovation. Networks of people, firms, clusters and regions have been used as an analogy to advance the understanding of innovation. According to (Dodgson *et al.*, 2013) , "A network is any system that can be described by a set of things or actors, and the connections between them".

A value network extends beyond just transactions around goods, services, and revenue. The strength of the value network exists in the interactions between the actors (Aarikka-Stenroos *et al.*, 2017; Allee, 2000; Peppard *et al.*, 2006; Verna, 2008). It enables exchange of tacit and explicit knowledge, technical know-how, policy development, process and product knowledge etc. In a value network, a clear understanding of the expectations by each network member is crucial (Peppard *et al.*, 2006). According to 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". The participants of a value network can be identified from the standpoint of the focal firm, wherein all actors who influence the value delivered by the focal firm to the end customer are active members of the value network. Networks can have a multitude of meanings and definition. Value network is perhaps a way to envisage how value is created by multiple firms working together.

During turbulent market environment, firms seek new ways of collaborations with unlikely partners in order to sustain their competitive advantage (Furr *et al.*, 2018). Firms refrain from developing new products and services alone when there is uncertainty in the market due to new technologies (Furr *et al.*, 2018). They instead try to engage with many partners in order to share resources and competences. This set up where multiple firms or actors collaborate together to develop value is often referred to as an ecosystem. Further, (Clarysse *et al.*, 2014) describe that the ecosystem construct is embedded in the idea of value networks.

3.4. THE ECOSYSTEM CONSTRUCT

The ecosystem approach was originally adapted from biology to the business context by (Moore, 1993) to illustrate a business ecosystem as network of actors characterized by interdependence and co-evolution. Two decades later, the use of the term in the field of management has proliferated (Scaringella *et al.*, 2018). An ecosystem consists of network of individual firms contributing their individual solutions to a common platform (or value proposition) in order to offer a complex value proposition (Adner *et al.*, 2010; Clarysse *et al.*, 2014). To create value to end customer, an ecosystem integrates complementary solutions developed by interconnected, yet independent actors (Dattée *et al.*, 2018). Today, the term 'ecosystem' has gained attention in research fields such as strategic management (Adner, 2017; Adner *et al.*, 2010; Jacobides *et al.*, 2018; Teece, 2007; Zhang *et al.*, 2007) and innovation management (Clarysse *et al.*, 2014; Gawer *et al.*, 2014). The concept of "ecosystem" has flourished in management and marketing literature (Aarikka-Stenroos *et al.*, 2017) with new conceptualizations such as "innovation ecosystem" (Adner *et al.*, 2010), "platform ecosystem" (Ceccagnoli *et al.*, 2012; Gawer *et al.*, 2014), "knowledge ecosystem" , and "entrepreneurial ecosystem"

Increasingly, management literature is also addressing value creation in the context of ecosystems (Adner *et al.*, 2016; Clarysse *et al.*, 2014; Dattée *et al.*, 2018; Jacobides *et al.*, 2018), thereby shifting away from the context of bilateral partnerships (Dodgson *et al.*, 2013; Madhok *et al.*, 1998; Teece, 1986). The strategy literature has predominantly focused on value capture and the firm's ability to establish competitive advantage by deploying its resources and competences and maintaining high bargaining power (Danneels, 2002; Teece *et al.*, 1997). This literature addresses the various roles played by firms in the value chain paying attention to the distinctions between focal firm, supplier, complementors, buyers etc. (Adner *et al.*, 2010). However, the bargaining power of a partner (a complementor, buyer or supplier) over the focal firm's ability to capture value is not analyzed as having an impact. The value capture potential of each actor, be it a supplier, buyer or complementor, is an important aspect of an ecosystem.

The ecosystem mode of operation replaces the ill-effects of vertical integration, hierarchy and direct control (Williamson *et al.*, 2012). According to Adner *et al.* (2010), although value chain suggests interlinks between various firms, the literature does not address the location of activities in a value chain and the difference between complements and components. In order to address the distinction between a component (e.g., software for hardware product; GPU in a computer) and a complement (e.g., mouse for computers; charging infrastructure for electric vehicles) and its role in enhancing the focal firm's innovation, the construct of an ecosystem has gained prominence in both academia and practice alike (Adner *et al.*, 2010). Industries such as biotech are typically organized as value chains where there is a clear division of labour between the different actors in the value chain (Clarysse *et al.*, 2014). However, ecosystems do not adhere to a linear value creation process. In an ecosystem, firms deliver value to end customers in a non-linear value creation process. Thus, an ecosystem can be broadly defined as network of firms with horizontal interdependencies (Clarysse *et al.*, 2014; Moore, 1993). In such inter-organizational networks, firms engage in both collaborative and competitive practices resulting a coopetition structure (Moore, 1993).

3.5. KEYSTONE FIRMS IN ECOSYSTEMS

In order to gain competitive advantage, ecosystem members need to exchange resources such as knowledge and the members should also be aware of their position, where value is created and how the relationships are established (Williamson *et al.*, 2012). By referring to dynamics between actors in a value network, business ecosystem theory Moore (1993) offers a new approach to collaborative relationships. Ecosystems, as the name epitomizes can "evolve through serendipity and self-organization" (Williamson *et al.*, 2012). A firm's resources and capabilities determine its role in the ecosystem and their relationship with other actors (Iansiti *et al.*, 2004). Not all actors occupy the same role or perform the same set of activities (Wulf et al., 2017). The development of an ecosystem is often attributed to a lead firm (or hub firm) that orchestrates various activities in the ecosystem. Iansiti *et al. (*2004) identify keystone, Dominators, Niche players and Hub landlords as the various roles that may be seen in an ecosystem. The keystone firms are considered to be the caretakers of the ecosystem who ensure the overall health of the ecosystem. Niche players on the other hand are seen on the peripheries of the ecosystem and channel important ideas and innovations into the ecosystem. Dominators or Landlords in turn are actors who seek to capture value, especially in a business ecosystem.

Iansiti *et al.* (2004) attribute two important roles of a keystone firm, namely "creating value" and "sharing value" with participants. They further state that, "Keystones can create value for their ecosystems in numerous ways, but the first requirement usually involves the creation of a platform, an asset in the form of services, tools, or technologies that offers solutions to others in the ecosystem[…]Keystone firms leave the vast majority of value creation to others in the ecosystem, but what they do create is crucial to the community's survival" (Iansiti *et al.*, 2004, p. 13). The keystone firm plays an active role in organizing activities and ensuring the overall health of the ecosystem (Williamson *et al.*, 2012). By promoting and enhancing the development of an ecosystem, this firm can shape the structure and functioning of the ecosystem.

Importantly, Iansiti *et al*., (2004) acknowledge four important ways by which the keystone firm can advance the development of an ecosystem, namely:

- Establish links between participants and simplify interactions to improve productivity
- Ensure third parties are able to develop products efficiently
- Enhance robustness by incorporating technological innovations that provide support for participants in reacting to new and uncertain conditions
- Encourage niche creation by providing the technologies to all third-party organizations

Thus, the health of the entire ecosystem depends on the keystone firm and removal of it may lead to the catastrophic collapse of the entire network.

The knowledge sharing activities of a keystone firm depends on the nature of the value creation network. Closely or densely embedded networks consists of intense exchange of resources in the form of knowledge etc. whereas a more open network is not easily influenced (Ahuja, 2000) and the keystone has less significance in such networks. Furr *et al.,*(2018) identify subtle changes in the role of the keystone firm depending on the nature of the ecosystem, if it is a centralized or an adaptive ecosystem. In a centralized ecosystem, a keystone firm (addressed as a broker) "connects to partners but keeps them separate, forcing them to work through itself". On the other hand, in an adaptive ecosystem, a keystone (addressed as orchestrator) "connects multiple partners and encourages them to work directly with one another" (Furr *et al.,* 2018, p.61). Explicit knowledge is easy to share between the keystone firm and its partners whereas tacit knowledge is embedded within a firm and its cumbersome for external actors to access or relate to its context (Adner *et al.*, 2010; Iansiti *et al.*, 2004; Williamson *et al.*, 2012).

The nature of formal and informal inter-organization relationship in an ecosystem also influences how the participants access and share knowledge (Wulf *et al.*, 2017). This also influences the trust and willingness to cooperate with each other. In this regard, the role of a keystone firm is crucial for the flow of knowledge throughout the ecosystem. Keystone firms can control and orchestrate the ecosystem by developing rules of engagement (Zahra and Nambisan, 2012) and maintain the flexibility of the ecosystem in adjusting to external threats and identifying new opportunities (Iansiti *et al.*, 2004).

4. METHOD

This chapter describes the methodological choices that have been used to address the research questions presented in chapter one.

4.1. RESEARCH APPROACH

A complex phenomenon, such as emergence of an ecosystem, wherein developments occur over time necessitates a long term perspective. This motivates a longitudinal study as it facilitates a deeper understanding of a specific context, i.e., how various agents (individuals) and units (teams) interact, and the underlying reasons for such interactions. Literature on ecosystem also highlight the need for longitudinal studies in order to understand the emergence of new ecosystem (e.g., (Gawer *et al.*, 2014; Jacobides *et al.*, 2018). Thus, the study tracked activities taking place within the AD technology development project at Volvo. The unique empirical context and the need to understand underlying reasons, motivations and opinions of individuals at the case firm warrants a qualitative study with longitudinal approach (Flick, 2014). In a qualitative study, the emphasis is usually on a "specific case, a focused and bounded phenomenon embedded in its context" (Miles and Huberman, 1994, p. 10). A longitudinal study facilitates a deeper understanding of a specific context, i.e., how various agents (individuals) and units (teams) interact, and the underlying reasons for such interactions. Further, in order 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).

4.2. RESEARCH DESIGN

A single case study design was deemed suitable as it allows for in-depth investigation of a phenomenon (Easterby-Smith *et al.*, 2012). Yin (2009) has suggested that a case study design is suitable when the focus of the study is to understand "how" and "why" questions and to investigate events that are difficult to control or manipulate. Although case studies do not have a universally accepted definition (Dubois *et al.*, 1999), this research uses Yin's (1994, p. 18) definition: "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 emergent and unique nature of the phenomenon, the research tended to be iterative (Dubois *et al.*, 2002; Siggelkow, 2007). The empirical data and theory were revisited concurrently to better understand the context. By moving back and forth between the empirical setting and theory, the research design is in line with the systematic combining approach (Dubois *et al.*, 2002). This meant that new questions emerged during the full course of the study.

Due to the interpretative nature of my research, I label it as "constructivist inquiry" (Lincoln, 1985; 2007). According to Guba *et al.* (1982), "positivist inquiry (quantitative) assumes a single reality and inquiry findings are based on a single reality". Whilst a constructivist considers multiple realities as an alternative explanation for social reality. Constructivist inquiry deals with research that is interpretative, and non-experimental in nature (i.e., non-positivist). This leads to abductive reasoning of the findings based on sense-making and perceptions of case (Gioia *et al.*, 2013). Data was collected ethnographically through observations, interviews and secondary sources. This type of data collection wherein the researcher is immersed in the case setting, as a 'participant as observer' can be described as an ethnographic method (Anderson, 2009; Yin, 2009).

4.3. Data collection

As part of the ethnographic method, I participated in team discussions and weekly meetings which allowed for collecting observational data in the form of field notes. Unlike other data collection techniques where researchers tend to ask specific questions, ethnography involves visiting the subject's location (field) in order to observe and listen in a non-intrusive manner. On the other hand, participant observation is a way to be in direct spatial relationship with the study object and enables the researcher to ascertain if what the interviewees say they do and what they actually do in reality tally (Mulhall, 2003).

To address the technique used to collect the field notes, I will use the term 'participant observation' to emphasize the fact that observations, along with interviews, were used to collect data whereas ethnography is my overarching research method. According to Atkinson *et al.*, (1998, p. 249), "Both ethnography and participant observations have been claimed to represent a uniquely humanistic, interpretive approach, as opposed to supposedly 'scientific' and 'positivist' positions". Distinguishing between 'ethnography' and 'participant observation' has been problematic and controversial, as scholars have used them interchangeably (Aktinson *et al.*, 1998). It has been argued that all forms of social research are a form of participant observation, because a researcher cannot study social contexts without being part of it (Atkinson *et al.*, 1998).

Table 1. Overview of data from the longitudinal study use in the appended papers

Paper	Type of data	Study context	Data collection
1	Field notes, interviews, and secondary data	The industry transformation	2016-2017
2	Field notes, and secondary data	The shift in way of working at the keystone firm	2018
3	Field notes, interviews, and secondary data	The importance of tactical activities in a new technology development project	2018-2019
4	Field notes, interviews, and secondary data	The emergence of a new innovation ecosystem	2016-2019

Observational data, in general, is useful to identify nonverbal expressions, who interacts with whom, how actors communicate with each other, and catalogue events as they unfold (Kawulich, 2005). Thus, the field notes are an important tool to document observations and it helped to ensure that there is little distinction between what has been observed and what has been interpreted by the observer (Flick, 2014). Along with observations, interviews were carried out and allowed for gathering additional information or check the accuracy of observations and gain new accounts of a problem based on personal experience (Easterby-

Smith *et al.*, 2012; Maxwell, 2012). The interviews were conducted in a semi-structured manner as it allowed room to discuss interviewee's experiences and interpretations on various subjects (Flick, 2014). Both observations and interviews are useful to gain insights about non-contemporary events that took place in the past or ones that cannot be observed (Maxwell, 2012). Interviews were documented through recordings and later transcribed. A total of 26 semi-structured interviews were carried out. Along with interviews, field notes amounting to 700 pages was collected. Additionally, secondary data in the form of press releases, archives, etc., were used to supplement the observations and interviews. The papers appended in the thesis were written at different periods and focused on various contexts (See figure 1). The use of data in the appended papers is further illustrated in Table 1.

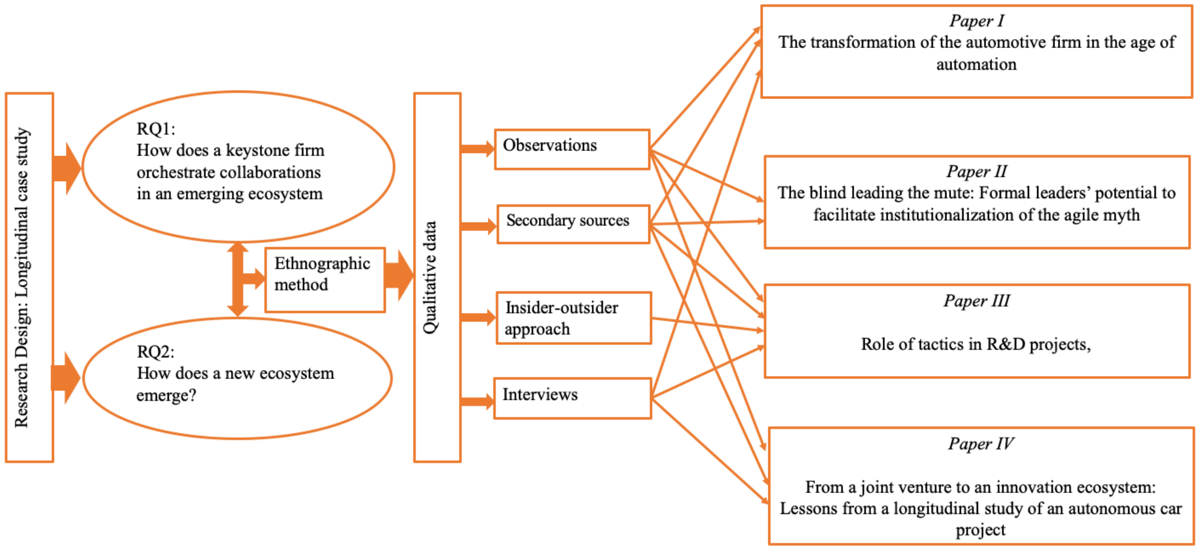

Figure 1. Relationship between research questions, type of data and the appended papers

4.4. Data analysis

The exploratory and longitudinal approach renders the research process to be iterative where data is collected and analysed in parallel. One of the issues that I faced during the initial phase of my study was that data piled up very quickly due to the frequency of field visits. Over time the sheer volume of data required a structured data analysis process (See table 2). Gioia *et al.* (2013) acknowledged this issue by expressing that it is quite normal to feel "lost" in the data analysis process. The rich data gathered would provide little value if not processed in a structured manner. Thus, I decided to do the data analysis concurrently with the data collection (Dubois *et al.*, 2002; Maxwell, 2012).

The interviews were transcribed and analysed using the data analysis software NVivo. The field notes were coded using the Xmind mapping tool during the first year of the study and later using NVivo. To categorize and identify patterns in the data, codes (shown as 'nodes' in the software) were generated on NVivo (Easterby-Smith *et al.*, 2012). The data was coded into non-hierarchical user-defined nodes, and the coding process was guided by theoretical framework. A few codes from NVivo are shown in figure 2.

Table 2. Data sources and quantity

Data source	Participant(s)	Type of data	Quantity	Time period
Stakeholder interactions	Senior managers	Semi-structured interviews	26	2016-2019
Informal discussions	Senior managers and managers	Photos of White board discussions, audio notes	–	2017-2019
Weekly meetings	Engineers, Product owners, Senior managers	Field notes	700 pages	2016-2019
PI planning	All employees	Field notes	Occurs every 12 weeks (Since June 2018)	2018-2019

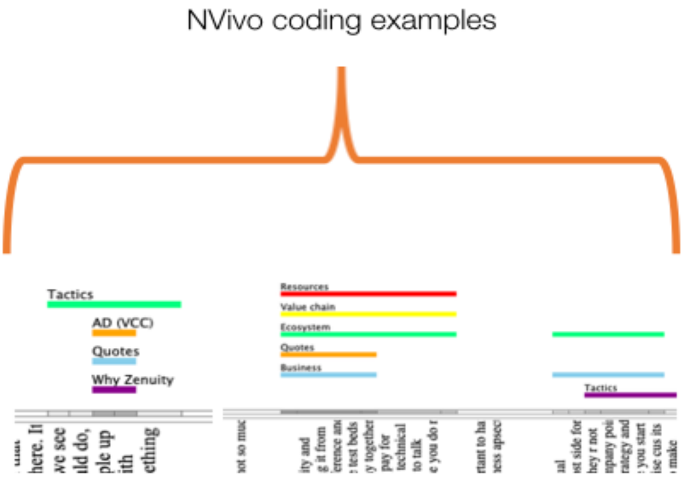

Figure 2. Examples of codes from NVivo

4.5. Research Quality

Any research undertaken by a single field-worker invites the question of validity and why the study should be accepted (Maxwell, 2012). Validity in general is concerned with the integrity of the results derived from the research (Easterby-Smith *et al.*, 2012; Saunders *et al.*, 2009). As a qualitative researcher, I intend to understand the phenomenon through relationships between different constructs. The validity of my research depend on the extent to which the findings provide a true representation of the phenomenon (Easterby-Smith *et al.*, 2012). In other words, validity delves into the integrity of conclusions generated from a research study (Bryman *et al.*, 2015). Although, the validity of results in not guaranteed by following a particular method, it is pertinent to discuss the relationship of the conclusion to the phenomenon studied (Maxwell, 2012).

To ensure valid and reliable results, as a researcher with constructivist epistemology, I used multiple methods to gather data (Golafshani, 2003). The use of multiple data sources in the form of interviews and observations helped access the experiences and perspectives of those in my case (Easterby-Smith *et al.*, 2012). Frequent interactions with the stakeholders at Volvo enhanced the understanding of the program context. Through co-authoring papers with peer researchers, I also accommodated the perspectives and ideas of additional researchers. Johnson (1997) addresses this as "investigator triangulation". Thus, triangulation in terms of including multiple sources of data and collaborating with peer researchers are two initiatives I took to improve the validity of study results (Golafshani, 2003).

It is pertinent to discuss trustworthiness of my research due to my qualitative approach and abductive reasoning of my findings. Trustworthiness is especially important in a single case design. The case that I investigate is unique and findings from the study are rooted in a real-life context offering an understanding of the phenomenon, i.e., the emergence of an ecosystem (Siggelkow, 2007). Case study research has sometimes been criticized, as results are difficult to generalize beyond the scope of the case (Easterby-Smith *et al.*, 2012; Siggelkow, 2007). By clearly describing the research context and inherent assumptions in the study, the study is expected to be useful for future investigations involving ecosystems and develop knowledge in the field.

5. SUMMARY OF APPENDED PAPERS

In this section, the four appended papers are summarized. The main contributions of each paper are presented, followed by a table indexing each paper to the research questions presented in section one. The method is not presented in-depth here as all four papers are based on data from the same longitudinal case study, presented in the method chapter.

5.1. PAPER I

The transformation of the automotive firm in the age of automation– Early findings from a case study of the Drive Me project at Volvo car Group

In recent times, research on inter-firm collaborations address the fact that firms have increasingly opened up their innovation processes to collaborate with other actors, ranging from suppliers to customers and even competitors. This is due to the rapid advancements in technologies that often render knowledge and resources of incumbents obsolete. Automotive industry is often attributed as a mature industry with hierarchical value chains built around OEMs. Electrification, autonomous mobility and ride hailing services are leading to a huge shift in the resource and competence base of the entire industry. The advancements in sensor systems and software in modern vehicles has increased the interactions between OEMs and non-automotive firms. Autonomous Drive (AD) technology is seen as a radical technological shift with a potential to transform mobility as we know today.

The purpose of paper I is to understand the challenges that incumbent automotive firms face in the transition to autonomous vehicles. The paper is based on a longitudinal case study of Volvo's AD program. Insights from the project[3] revealed that the nature of activities in the AD program are in stark contrast to traditional projects in the automotive industry. The paper argues that the established value chains in the automotive industry is unfit for developing autonomous drive (AD) technology. Value chain thinking has been the most useful way to understand the functioning of traditional industries churning out physical products (Allee, 2000). The empirical observations at Volvo's AD program show that the value chain way of organizing

[3] Paper I & III address the AD program as a project. This is due to the recent transition of Volvo's "AD technology development" from a project to a program

activities between OEMs and suppliers is giving way for a value network. The type of collaborations and competences needed for the AD program necessitated that Volvo engaged itself in a value network where all actors possess significant competences and know-how. Further, high levels of complexity with technologies (such as GPUs, Cloud network, Lidar, Radar etc.) and uncertainty with legislation, technology standards etc. rendered the traditional waterfall way of working unfit.

Paper I makes two important contributions regarding the development of AD tech. Firstly, the development of value networks in the automotive industry due to the changing innovation landscape. Secondly, the need to shift from traditional waterfall way of working in order to handle the software development activities that is becoming a major part of development activities in the automotive industry. Paper I highlights the major differences between a traditional car development project and an autonomous car project based on new technology development.

5.2. PAPER II

The blind leading the mute: Formal leaders' potential to facilitate institutionalization of the agile myth

More and more firms are moving from plan-driven to an agile approach to new product development. New product development in a firm relies on formally designed plan-driven development processes. The formal processes are often complemented by informal structures and are considered indispensable to the development of new products. In recent times, many firms have embraced agile development methods in order to handle the dynamic environmental context (Rigby *et al.*, 2016). The popularity of the agile development approach has significantly altered the nature of planning and executing tasks. The purpose of the paper is to illustrate a paradox whereby agile development constrains the existing agility embedded in informal structures.

Firms deep entrenched in traditional structured development approaches (e.g.: waterfall) that promote formalized, sequential development style are increasingly attracted by the promises that agile provides. Agile is seen as a way to promote flexibility in the product development that is often seen as the weakness with plan-driven processes. However, the shift from traditional to agile is not without challenges (Dikert *et al.*, 2016) and is a conundrum for formal leaders pioneering the transition.

Whist informal networks and self-organizing employees inspire the formal adoption of agile, institutionalizing agile nevertheless leads to the disruption of informal networks and established relationships. This paradox is exemplified in the paper by drawing on theory of institutional work. The paper is based on a longitudinal case study from an AD technology development project that recently shifted from plan-driven to agile development. Using observations from a longitudinal study, Paper II exemplifies the role of formal leadership in the institutionalization of agile.

This paper maps activities inside the AD program and addresses the internal challenges encountered by the keystone firm of an emerging ecosystem. The findings address how formal leaders can address the institutionalization of agile and contributes to literature on agile development by underlying the conflicts that arise during a transition from plan-driven way of working to agile.

5.3. PAPER III

Role of tactics in R&D projects

This paper builds upon the data collected during the agile transformation at Volvo's AD program. The interest for this paper originated from the frequent use of the word "Tactics" by a senior manager (also my stakeholder at Volvo). He felt that the uncertainty and complexity in developing an autonomous car necessitated a tactical mindset. This invoked an interest in understanding the duality between agile and tactics. Both strategy and tactics are established in literature as essential for project success (Ackoff, 1970; Casadesus-Masanell *et al.*, 2010; Moe *et al.*, 2012; Schultz *et al.*, 1987). Despite the well-established importance of both tactics and strategy for project success (Slevin *et al.*, 1987), few academic works have addressed the use of tactics in Agile projects.

The purpose of the paper is to understand how agile methodology supports R&D projects in being tactical. It draws on data from the longitudinal case study and insights from the senior manager who is also a co-author of the paper (Asselin, 2003). From the data, four observations were selected to elucidate the need for tactics in the AD program and the impact of agile way of working in executing tactics.

The legal framework uncertainty: The regulatory uncertainty surrounding autonomous vehicles necessitated the AD project to be prepared for making changing to hardware and/or software. To handle this uncertainty, the project develops multiple tracks that gives flexibility in the development process.

The documentation trade-off: This an example from an agile team level. When a task to prepare documents explaining the codes, the team decided to find an alternate solution for the task assigned to the team. It was seen that agile empowered the teams to discuss the work and develop their own internal plans. The flexibility was a key aspect of agile methodology.

Handling unknowns: Due to the rapid advancements in sensor system, it is important for the AD technology to freeze the sensor system as late as possible. In order to handle this uncertainty, the project uses an Operational Design Doman (ODD) that frames the operational conditions under which an automated feature is designed to function. When there is new functional needs, the ODD can be expanded to incorporate more advanced functions.

Suppliers and components: Technologies such as Lidar, sensor, cameras, GPU, etc. are continuously improving in performance and cost. Also, suppliers of such technologies and services are often locked to a particular market or geography. Volvo needs to ensure that the AD project can handle emergent challenges pertaining to suppliers or technologies. This requires flexibility in the development process and an ability to handle changes in the supply network.

Literature on agile development methods abundantly illustrate its advantages in terms of being conducive for fast changes, cross-functionality, improved collaboration etc. In a waterfall way of working, focus is on reducing uncertainty and curtails making changes to plans. This is seen as unfit for developing new technologies where tactics is considered highly essential in handling emergent challenges. From observations and insider experiences, the paper argues that agile way of working allows for tactical activities in a new technology development project.

5.4. PAPER IV

From a joint venture to an innovation ecosystem: Lessons from a longitudinal study of an autonomous car project

Literature on ecosystem recognizes the lack of knowledge on the emergence of a new ecosystem as they are rarely studied in their emergent phase. Part of the challenge pertains to the rare occurrence of "new ecosystems" and the rather ex-post definition of ecosystems (Gawer *et al.*, 2014; Jacobides *et al.*, 2018). An ecosystem is described as a constellation of actors working together in creating value (Adner, 2006; Gomes *et al.*, 2018; Jacobides *et al.*, 2018; Moore, 1993), thereby rendering a shift from value chain perspective to value network (Peppard *et al.*, 2006).

Today, the notion of ecosystem is encompassed in more nuanced constructs such as hub ecosystem, innovation ecosystem, business ecosystem, open innovation ecosystem, etc. Literature on ecosystem attributes modular architecture as being vital to ecosystem attractiveness. However, achieving modularity is often seen as cumbersome process and largely dependent on the degree of control asserted by the keystone firm. In this context, it is important to develop new knowledge that explains how firms achieve modularity – accidental or intentional – in new technology development and the role of a keystone firm in using the modular technology to orchestrate the emergence of a new ecosystem. The purpose of Paper IV is to explore how an incumbent firm engages in collaborations to develop a new technology. To do so, the paper builds upon data from a longitudinal case study at Volvo's AD technology development project.

The resource and competence needs of the project pushed VCC to form a joint venture with Autoliv, a leader in automotive safety systems. The findings show that the joint venture (Zenuity) and the parent (Volvo) shared a "symbiotic" relationship. Zenuity intended to supply software for all OEMs which meant that it developed software compatible to all OEMs in the industry. Due to this set up, activities in the AD program were inherently aimed at establishing modularity. The symbiotic relationship between Zenuity and Volvo resulted in the development of a modular technology platform. Thus, the software development for AD technology through a joint venture, beyond the direct advantages of augmenting resources and competence, implicitly nurtured the formation of an innovation ecosystem.

Paper IV argues that the AD program achieved modularity due to the unique nature of its joint venture partnership. Further, the findings show how Volvo transitioned from a parent firm of a joint venture to a keystone firm in an emerging ecosystem.

5.5. Linking the papers to the overall purpose of the research

The four papers appended to this licentiate thesis are all based on the longitudinal case study at Volvo's AD program but are investigating different perspectives of the "technology development" program. Table 3 shows the relation between the papers and the research questions.

Table 3. Mapping the research questions to the appended papers

Research Questions	Paper I	Paper II	Paper III	Paper IV
1) How does a new ecosystem emerge?	☒			☒
2) How does a keystone firm orchestrate collaborations in an emerging ecosystem		☒	☒	☒

Paper I was drafted during the early phase of the study. During this phase, I focused on understanding the AD program. The findings (Paper I) highlight the network form of collaboration between Volvo and other actors. It also highlights the shortcomings of Volvo's waterfall way of working and argues for the need to change this development approach to better engage with other actors in the network. This paper sets the foundation for my focus on value networks and exploring the ecosystem dimension of the AD program.

Paper II and III discuss the AD program's shift from waterfall to agile way of working. These findings offer important insights on the changes in the way of working in the AD program. Paper II discusses the agile transformation at Volvo's AD program. In particular, Paper II highlights the challenges faced by a firm when changing its established ways of working and the paradoxes involved with institutionalizing agile development method in a large firm. Volvo's waterfall way of working created challenges with collaborating with other actors, especially software firms, such as Zenuity. The agile transformation was an important aspect of Volvo's efforts to improve the development work in the AD program and better synchronize development activities with its partner firms.

Paper III also shows the importance of establishing efficient ways of working to share resources and competences with other actors. This paper provides insights on the importance of tactics in R&D projects and agile as an appropriate way of working to facilitate tactical activities in a project. Again, although being on a project level, this paper contributes to the understanding of Volvo's transformation as a keystone firm. Literature on ecosystem highlight flexibility and awareness to the external environment as an important role of the keystone firm. Thus, agile facilitating tactical activities enhances Volvo's ability to adapt towards new challenges and opportunities in the ecosystem. Although both Paper II & III discuss Volvo's agile transformation, the findings are highly relevant to understand the collaborations in the ecosystem where most of the activities are centred around developing software features with many of the partner firms using the agile development method as their modus operandi.

Paper IV explains the various collaborations in the AD program with particular focus on the joint venture established by Volvo and Zenuity. The paper addresses the emergence of new ecosystem by focusing on the "symbiotic" relationship between Volvo and Zenuity. This was identified as a reason for the development of a modular technology platform, often cited as a cornerstone of ecosystem emergence. The paper shows the increase in the number of collaborations and attributes it to Volvo's ability to embed modularity in its technology development. Most firms struggle to establish an ecosystem due to the difficult in achieving a modular technology platform. Developing modularity involves reduced development speed and increased cost. However, the existence of a JV with the responsibility to develop software and the JV's vision of supplying AD software to all OEMs implicitly resulted in a modular technology platform. Thus, paper IV shows the emergence of Volvo's AD ecosystem by tracing the origins of several collaborations in the AD program. An overview of the study is depicted in Figure 3.

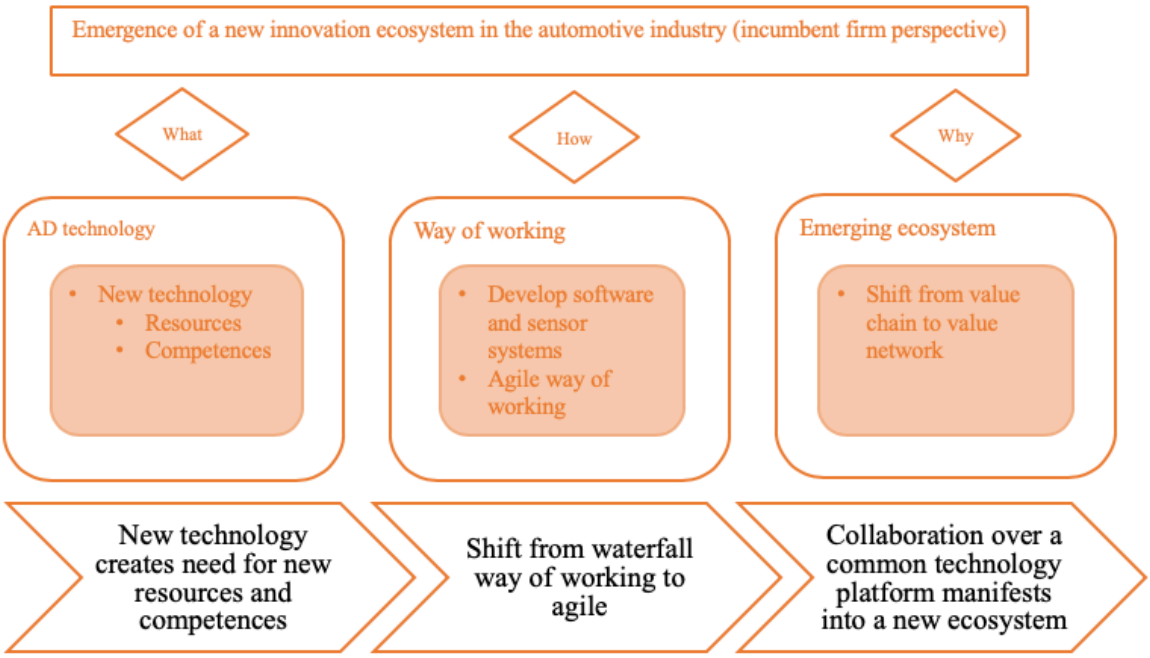

Figure 3. Overview of the study

6. DISCUSSION

The following sections discuss the findings of the longitudinal study in relation to the research questions and links them to the respective papers appended in the thesis. The final section revisits the research questions and provides a summary of the findings.

6.1. DEVELOPING A NEW TECHNOLOGY IN A VALUE NETWORK

Historically, the automotive industry has been a text book example of a value chain consisting of suppliers, distributors, Original Equipment Manufacturers (OEMs) and retailers. The advent of AD technology has altered the competitive landscape of the automotive industry. In the early phase of the longitudinal study, it was noticeable that the project had multiple partners from outside the automotive industry. AD technology is heavily dependent on software development and sensor fusion which necessitates that Volvo collaborates with non-automotive firms. These firms possess knowledge that the OEM's (Volvo) traditional value chain lacks.

The AD program consists of multiple actors who operate in a non-sequential manner where value is created independently of each other but aimed at enhancing the technology platform

(Paper I & IV). For example, Uber develops its AD features independent of Volvo's AD cars but shares the AD car platform with Volvo. This facilitates both Volvo and Uber to share the resources and competences to build the technology platform yet does not restrict them to pursue their independent business objectives. Similarly, Zenuity is allowed to commercialize its software solutions to other OEMs. This is in contrast to a value chain where development work proceeds in a sequential manner from raw materials, followed by manufacturing, and then distributing the finished goods to the end customers. The AD program thus departs from the value chain mode of operations that is usually the norm in the automotive industry (see figure 4). Instead, it is a collaborative innovation project where value is created in a network with all actors playing a vital role in creating and delivering value (Peppard *et al.*, 2006). However, this set-up was a significant challenge for Volvo as it is attuned to value chain mode of operations.

Further, Paper I highlights the need to change the traditional waterfall way of working in order to handle the software development activities that is becoming a major part of development activities in the automotive industry.

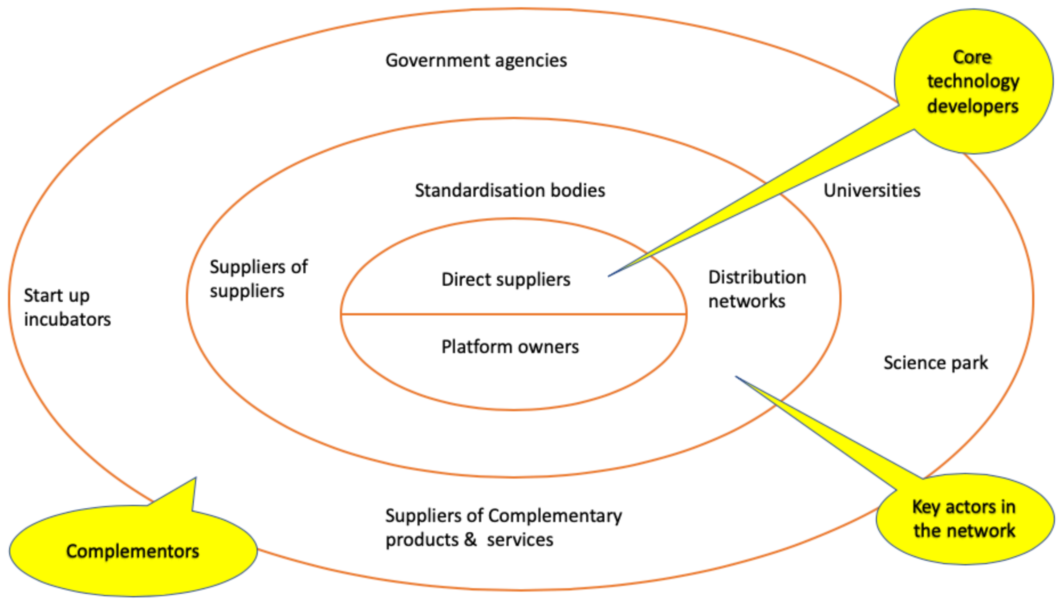

Figure 4. A typical value network. Adapted from Moore (1993) and (Alizadeh *et al.*, 2017)

6.2. Agile transformation

Early on, Volvo's waterfall development method created bottlenecks in the project as most actors, including Zenuity, operated with agile development methodology (paper I, IV). The plan-driven waterfall way of working is tailor made for an industry steeped in the sequential value chain (Norman & Ramirez, 1993). However, with the increase in digital features, the need to develop software necessitated a change in the entire way of working. Initially, the AD program faced challenges due to the difficulty in adapting to value network and the waterfall way of working compounded the challenges in interactions between the actors (paper I). In order to synchronize activities in the emerging AD ecosystem, Volvo's AD program adopted an agile way of working. This was an important milestone in Volvo's path to becoming a keystone firm. By adapting to agile, which is acknowledged to promote flexibility, Volvo could better address the challenges and opportunities in the ecosystem. It also helped Volvo synchronize activities with various actors in the ecosystem.

The findings in Paper I discusses the challenges that Volvo faced in developing AD technology due to its plan-driven waterfall way of working. Based on the empirical data, Paper I argues that Volvo needs to revisit its way of working in order to adapt to changing competitive landscape in the industry (i.e., shift in competition from hardware products or features to digital features or services). Paper I also highlights how Volvo's AD technology development project was constructed in a value network fashion. In 2018, as evinced in Paper I, Volvo made a shift from waterfall to agile development method. In seeking closer interaction with all actors, the AD program perceived agile development methodology as a better way of working in a value network. This further strengthened the claims made in Paper I about the need to shift the way of working to engage in value networks.

Given the advantages of agile development methods (e.*g., Scrum, Kanban, Extreme Programming (XP), Feature Driven Development (FDD), Lean etc*.) in developing digital technology, the transformation from waterfall to agile (especially in a large organization) is not without challenges. The transition from a plan-driven waterfall way of working to agile development in the AD program entailed significant challenges. Initially, employees perceived the shift to agile as difficult and challenging (Paper II). However, they also understood the importance of the transition and its impact on the future of the AD program. The agile transformation greatly improved the sharing of knowledge and resources between the various actors in the AD program (Paper III). Thus, paper II highlights how formal leaders can address the institutionalization of agile and contributes to literature on agile development by underlying the conflicts that arise during a transition from plan-driven way of working to agile.

Further, Paper III elucidates the usefulness of agile development approach in the projects ability to be tactical in the day-to-day activities. Literature on project management has adequately addressed the importance of both strategy and tactics for project success (Hadar *et al.*, 2008; Pinto *et al.*, 1990; Slevin *et al.*, 1987). Applying this theoretical framework, in Paper III, we identify that the previously used waterfall way of working in the AD program significantly restricted tactical activities. Thus, by addressing the importance of tactical activities in the AD program, Paper III sheds light on the usefulness of Agile way of working beyond the attributes highlighted in mainstream literature on Agile. Through various observational data and "insider-outsider" approach (Asselin, 2003), Paper III argues that the agile way of working facilitates tactical activities in a project.

6.3. MODULARITY AND ECOSYSTEM

The AD program began as an internal innovation project. The complexity of the project pushed Volvo to set up a joint venture with Autoliv. The JV was set up to develop the entire software system for the AD technology. To this effect, both parent firms transferred resources (such as intellectual property, personnel etc.) to the JV. Additionally, commercializing the AD software to all OEMs was also attributed as one of the reasons for setting up the JV. Thus, Zenuity (the JV) was allowed to develop products independent of Volvo's interference and functioned as an independent software supplier for AD vehicles. Paper IV identifies this as a key step in the emergence of the ecosystem.

Literature on ecosystems highlights the lack of empirical studies on the emergence of a new ecosystem (Gawer *et al.*, 2014; Jacobides *et al.*, 2018). This is primarily due to the fact that ecosystems in general have an ex-post definition and tracing the emergence of an ecosystem needs a long term perspective. The longitudinal study at Volvo led to findings that add significant contribution to literature on the emergence of an innovation ecosystem. In Paper I, it is established that Volvo's AD program is embedded in a value network where all actors participate in the value creation activities in a non-linear fashion. In Paper IV, the findings from the longitudinal study explains how the ecosystem around Volvo's AD program emerged. Through interviews, observational data (participant as observer), planning workshops and stakeholder interactions, Paper IV identifies the role of a 'symbiotic' JV in the emergence of an ecosystem.

The JV, with its ambition to be a supplier of AD software for all OEMs, had to ensure that its features were compatible to all potential customer. Due to the dependence of the AD program on Zenuity's AD software, Volvo implicitly developed a modular system that interfaces with Zenuity's software. Developing modular systems are difficult in the early stage of a new technology due to the uncertain market potential of the technology. Further, focusing on modularity may increase the cost and slow down the pace of development. Although frustrating to develop, literature on ecosystem identifies modularity is an important element of an ecosystem as it facilitates in integrating complementary innovations and services onto a technology platform (Gawer *et al.*, 2002; Gawer *et al.*, 2007; Iansiti *et al.*, 2004; Jacobides *et al.*, 2018). With modularity being an unintended consequence of setting up the JV, Volvo was able to attract more partners to its AD program. Over time, the number of partner firms in the AD program increased significantly (see figure 5). Thus, Paper IV makes important contribution to the knowledge on the emergence of new ecosystem addressing the gap in the ecosystem literature (Jacobides *et al.*, 2018). By owning the technology platform and externalizing software development, Volvo could orchestrate the activities in the AD program and position itself as a keystone actor.

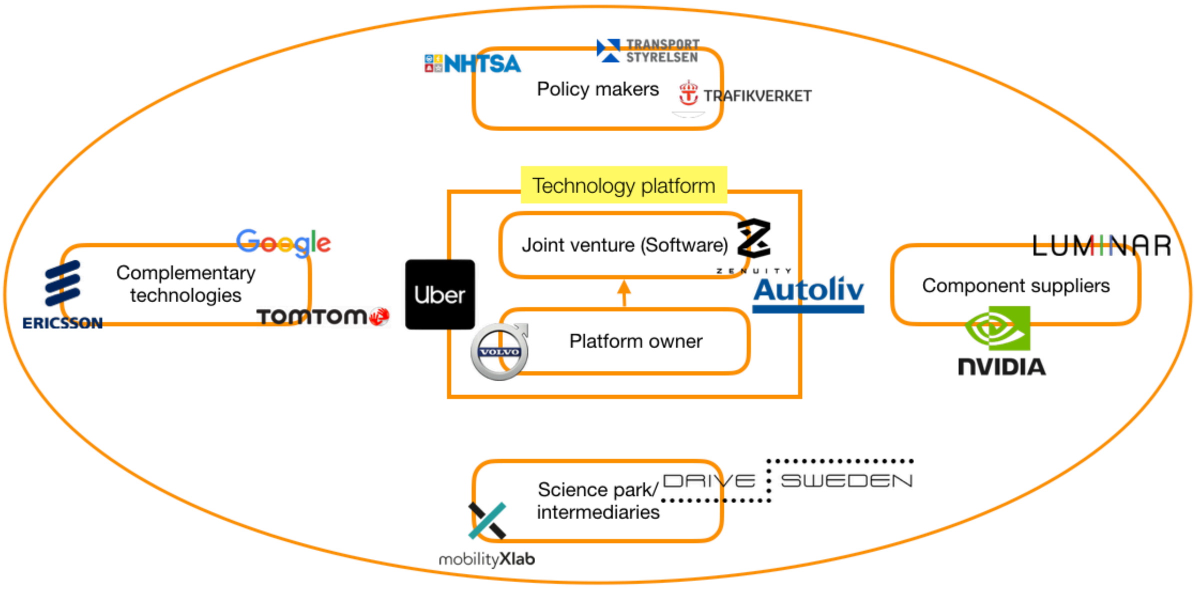

Figure 5. illustration of the emerging AD ecosystem (Source: author)

6.4. VOLVO AS THE KEYSTONE FIRM OF THE ECOSYSTEM

One of the biggest challenges that Volvo faced was pertaining to its plan-driven waterfall way of working that was unsuitable for new technology development project with high complexity and uncertainty. This also hindered Volvo's ability to coordinate activities with other actors (especially Zenuity). Also, AD technology is a complex system that consist of several digital technologies that needs to be integrated and processed by algorithms. This typically involves machine learning, activities that demand flexibility and adaptability. Volvo's waterfall way of working was unsuitable to carry out such development activities. The agile transformation significantly improved Volvo's ability to coordinate and cooperate with other actors in the emerging ecosystem (Iansiti *et al.*, 2004; Jacobides *et al.*, 2018). This, coupled together with Volvo's ownership of the base car platform and Zenuity's software, positioned Volvo as a keystone actor in the ecosystem.

Literature on ecosystems highlights the importance of the keystone firm (Adner *et al.*, 2016; Iansiti *et al.*, 2004; Jacobides *et al.*, 2018), that maintains the balance in an ecosystem and coordinates activities between the actors. The longitudinal case study argues that Volvo's 'symbiotic' joint venture facilitated the emergence of the AD ecosystem with Volvo as the keystone actor (paper IV). Although other actors like Uber, Baidu, Nvidia etc. had significant know-how and competences, Volvo was the facilitator of the partnerships and owned the base car (i.e., car platform) used for developing the AD technology. Volvo, as an OEM has the manufacturing, supply networks and infrastructure needed to integrate the AD technology into cars. The AD technology needs to be integrated with a product (i.e., car) for the end customer to perceive value. And, all actors in the network play important roles in the value that Volvo intends to provide its end customer (Dattée *et al.*, 2018). Thus, Volvo has to rely on all the participants in the ecosystem and ensure that all actors could coordinate activities with one another (Iansiti *et al.*, 2004). This positioned Volvo as a central actor that organizes activities and connects network participants (Iansiti *et al.*, 2004). Also, Volvo actively engaged with government agencies across the world (e.g., NHTSA in the U.S.; Transportstyrelsen and Trafikverket in Sweden) in order to facilitate the commercialization of AD technology (Paper IV). By holding key assets, supply networks and manufacturing capabilities, Volvo could play the role of an orchestrator in the ecosystem. All these attributes greatly helped Volvo position itself as the keystone actor in the emerging AD ecosystem (Paper IV).

Despite owning the core technology platform, Volvo did not hesitate to share value with other actors, *identified by Iansiti et al. (2004) as an important character of a keystone firm*. For instance, Uber pursues its own business interest in the area of ride sharing services and develop new offerings to suit its business needs (paper IV). Zenuity, on the other hand, develops its ADAS and AD software using Volvo's car platform. However, Volvo does not restrict Zenuity's ability to commercialize its software solution. This allows Zenuity to commercialize its AD solutions to all OEMs, despite Volvo being its parent firm and a key competitor to other OEMs (paper IV). Further, collaborations with technology firms like Nvidia allows Volvo to access critical knowledge and competences in the area of semiconductor technology. Firms such as Tesla, for example, develop their own propriety chipsets leading to closed technology platform (www.tesla.com/autopilot). Other actors such as Luminar, Ericsson etc., develop technologies or solutions that improves Volvo's AD technology. In line with literature on keystone firm (Iansiti *et al.*, 2004), by allowing others to develop services, tools, or technologies, Volvo shows that it is willing to both create and share value with other actors.

Thus, the keystone firm is the de facto coordinator of activities in an ecosystem (Iansiti *et al.*, 2004) and the shift from waterfall to agile way of working greatly improved openness and flexibility in the ecosystem (Paper III & IV). In an adaptive ecosystem (Furr *et al.*, 2018), the keystone firm needs to be flexible as it is difficult to predict the resource and competence requirements (Furr *et al.*, 2018). The keystone firms also needs to be wary of new trends and opportunities that may arise in the external environment. Thus, being tactical is of utmost importance in an adaptive ecosystem and the agile way of working greatly enhances the AD program's ability to adjust according to emergent needs (Paper III).

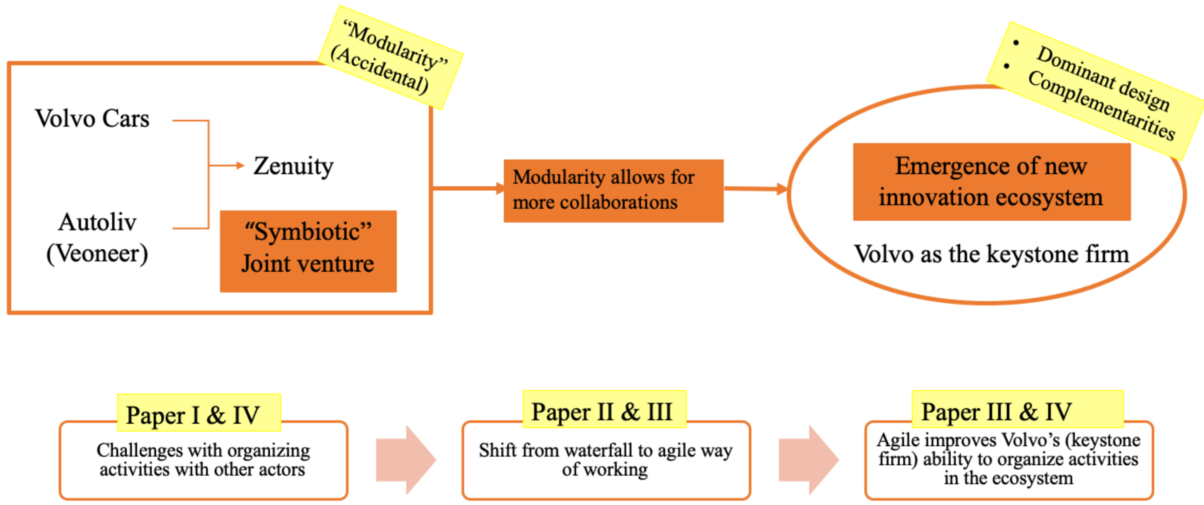

Figure 6. Volvo's transformation as the keystone firm of the ecosystem

6.5. The emergence of innovation ecosystems

The literature posits that all ecosystems consist of at least one keystone firm that coordinates the activities in the ecosystem. Further, modular platforms are quintessential for an ecosystem as they allow multiple actors to develop complementarities and integrate their value offerings with those of the platform. However, two questions pertaining to ecosystems remain inadequately studied. First, the factors that attribute to the emergence of an ecosystem. Second, how does a firm (incumbent automotive firm in this study), position itself as a keystone actor in a new ecosystem. These two important questions are addressed through this longitudinal study of Volvo's AD program.

How does a new ecosystem emerge?

Literature identifies that new technologies are often faced with unclear standards and lack of complementary assets (Adner *et al.*, 2010; Gawer *et al.*, 2007; Tripsas, 1997, 2009). This is a major challenge in commercializing new technologies. Standardization of a new technology is important to usher the development of complementary assets, infrastructure and government policies. Such challenges, pertaining to developing and commercializing new technology, are usually overcome by a network of actors working together in a manner akin to a biological ecosystem (Moore, 1993).

In management literature on ecosystems, modular platforms are identified as the cornerstone of an ecosystem (Scholten & Scholten, 2012). However, firms are often unwilling to embrace modularity in the early stage of a new technology development. This is because, developing modular technologies can be time consuming and expensive. Modularity often takes a back seat and is often considered an irrational objective during the early stages of technology development, especially when market potential and customer demand for the new technology is unclear. Instead, modular technologies usually emerge during the late-cycle of a new technology when the management attention shifts to outsourcing, achieving economies of scale and reducing development costs.

However, from an ecosystem perspective, modularity forms the core of the ecosystem. In the longitudinal case study, it was evident that the formation of a JV to develop software implicitly resulted in the modularity of Volvo's AD technology. This can be seen as an important advantage of the AD program and resulted in the increase in new collaborations. The results contribute to literature on ecosystems by addressing how modular platforms can be developed and the role of a keystone actor in orchestrating the emergence of an ecosystem. By showing these factors that contribute to the emergence of an ecosystem, the case study addresses the question on how ecosystems emerge.

How does a keystone firm orchestrate collaborations in an emerging ecosystem?

The second contribution of this longitudinal case study is the illustration of the shift in Volvo's role from being an OEM in a traditional value chain to a keystone actor in an emerging ecosystem. Literature on ecosystems shows that the keystone firm enjoys several advantages, however, not all firms are capable of becoming one.

Findings from the longitudinal case study illustrated the efforts taken by the incumbent firm (Volvo) to become a keystone actor. Along with the development of a modular technology, a change in the way of working significantly improved the incumbent firm's ability to coordinate activities in the ecosystem. Literature on ecosystem highlights the role of a keystone firm in coordinating the activities and sharing of resources. In this emerging ecosystem, the complexity of the technology, the unclear market demand and the uncertainty in legislation necessitated that the entire ecosystem was flexible in adapting to change. In this scenario, implementing agile as a development method significantly improved the incumbent firm's ability to organize activities in the ecosystem. Agile, as a way of working that exemplifies flexibility and adaptability to changes in the environment, facilitated the incumbent firm to better coordinate activities in the AD program. With a modular technology and flexibility in the organizing activities, the incumbent firm was able to orchestrate the emergence of a new innovation ecosystem and positioned itself as the keystone firm.

7. CONCLUSIONS

This licentiate thesis set out to understand the emergence of an ecosystem and how an incumbent firm can position itself as a keystone actor in the ecosystem Through a longitudinal study, this thesis shows how the case firm (incumbent in the automotive industry) leveraged on its JV to establish a modular technology and attracted other firms to collaborate in the technology development. The ownership of a modular technology facilitated the keystone to enable other actors to develop complementarities. This, according to literature, enhances a new technology's potential to become a dominant design. The development of a modular technology through a JV, and the establishment of multiple collaborations to develop features and services for the technology platform, led to emergence of a new innovation ecosystem and positioned the case firm as the keystone firm.

8. FUTURE STEPS

The ecosystem studied as part of this licentiate thesis is a closed system where the primary goal is "value creation" (i.e., innovation ecosystem). Innovation ecosystems are closed networks where transactions occur amongst actors that participate in creating value (Jacobides *et al.*, 2018). As the ecosystem develops, new challenges arise related to appropriating this value. To move from "value creation" towards "value capture", all actors must collaborate and persevere for common standards for the technology (Brem *et al.*, 2016). In literature, the value creation ecosystem is addressed as an innovation ecosystem (Adner *et al.*, 2016; Gomes *et al.*, 2018; Oh *et al.*, 2016) and the value capture ecosystem as a business ecosystem (Adner, 2017; Moore, 1993). In an innovation ecosystem, the primary objective is to develop value in the form of a product or service. In a business ecosystem, actors are motivated by commercial prospect of the new product or service.

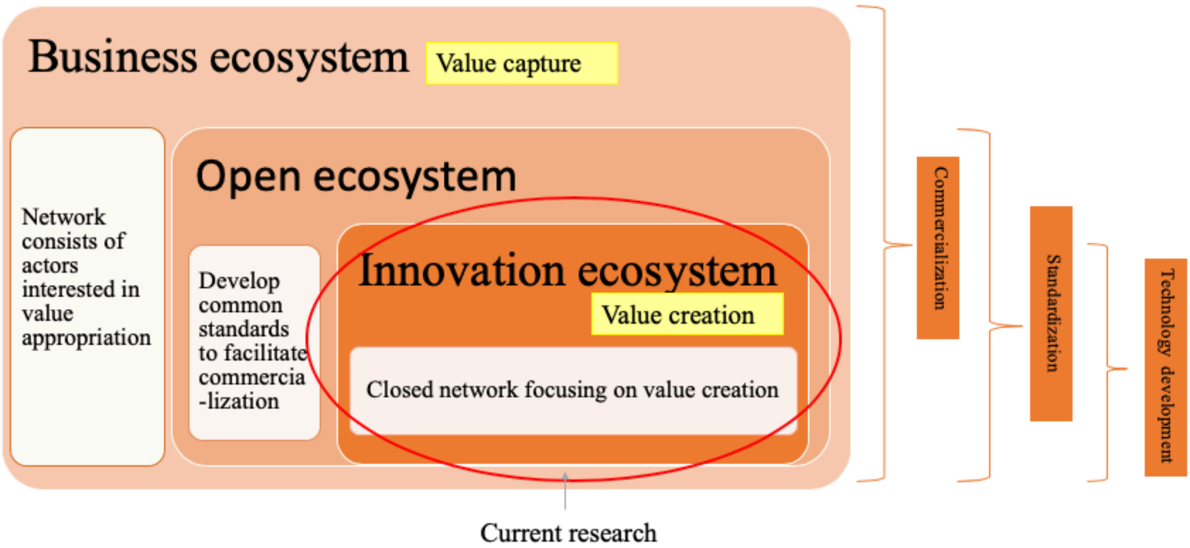

Figure 7 From value creation to value capture

This process of moving forward from an "innovation ecosystem" towards a "business ecosystem" necessitates a platform where all actors, from industry incumbents, to start-ups, to universities, can work together with the common goal of establishing standards for a new technology (see figure 7) (Gawer *et al.*, 2014; Rohrbeck *et al.*, 2009; Williamson *et al.*, 2012).

The plan for the second part of my PhD research is to better understand how an innovation ecosystem matures into a business ecosystem and the role of the keystone actor in facilitating this transformation, as outlined in Figure 8.

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.

Abernathy WJ, Utterback JMJTr. 1978. Patterns of industrial innovation. **80**(7): 40-47.

Ackoff RJLRP. 1970. A concept of corporate planning. **3**(1): 2-8.

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.

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.

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

Ahuja G. 2000. Collaboration Networks, Structural Holes, and Innovation: A Longitudinal Study. *Administrative Science Quarterly* **45**(3): 425-455.

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

Alizadeh N, Effati Dariani H, Smida A. 2017. Business Ecosystem, a Secured Strategy to Gain Competitive Advantage According to SMOCS Model. *International Business Research* **10**: 72.

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

Anderson K. 2009. Ethnographic research: A key to strategy. *Harvard Business Review* **87**(3): 24.

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

Asselin MEJJfNiPD. 2003. Insider research: Issues to consider when doing qualitative research in your own setting. **19**(2): 99-103.

Bimbraw K. Year. Autonomous cars: Past, present and future a review of the developments in the last century, the present scenario and the expected future of autonomous vehicle technology. In Proceedings of the 2015 12th International Conference on Informatics in Control, Automation and Robotics (ICINCO).

Brem A, Nylund PA, Schuster G. 2016. Innovation and de facto standardization: The influence of dominant design on innovative performance, radical innovation, and process innovation. *Technovation* **50-51**: 79-88.

Bryman A, Bell E. 2015. *Business research methods*. Oxford Univ. Press: Oxford.

Burke A, Abeles E, Chen B. 2004. The Response of the Auto Industry and Consumers to Changes in the Exhaust Emission and Fuel Economy Standards (1975-2003): A Historical Review of Changes in Technology, Prices and Sales of Various Classes of Vehicles.

Casadesus-Masanell R, Ricart JE. 2010. From Strategy to Business Models and onto Tactics. *Long Range Planning* **43**(2): 195-215.

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

Christensen CM, Rosenbloom RS. 1995. Explaining the attacker's advantage: Technological paradigms, organizational dynamics, and the value network. *Research Policy* **24**(2): 233-257.

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.

Danneels E. 2002. The dynamics of product innovation and firm competences. *Strategic management journal* **23**(12): 1095-1121.

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.

David PA. 1985. Clio and the Economics of QWERTY. *The American economic review* **75**(2): 332-337.

Dikert K, Paasivaara M, Lassenius C. 2016. Challenges and success factors for large-scale agile transformations: A systematic literature review. *Journal of Systems and Software* **119**: 87-108.

Dodgson M, Gann DM, Phillips N. 2013. *The Oxford handbook of innovation management*. OUP Oxford.

Dubois A, Gadde L-E. Year. Case studies in business market research-An abductive approach. In Proceedings of the In McLoughlin, D. and Horan, C.(eds) Proceedings of the 15th Annual IMP Conference, University College Dublin, Spetember.

Dubois A, Gadde L-E. 2002. Systematic combining: an abductive approach to case research. *Journal of Business Research* **55**(7): 553-560.

Easterby-Smith M, Thorpe R, Jackson PR. 2012. *Management research*. Sage.

Flick U. 2014. *An introduction to qualitative research*. Sage.

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

Galunic DC, Eisenhardt Km. 2001. Architectural Innovation and Modular Corporation Forms. *Academy of Management Journal* **44**(6): 1229.

Gawer A, Cusumano MA. 2014. Industry Platforms and Ecosystem Innovation. *Journal of Product Innovation Management* **31**(3): 417-433.

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

Gawer A, Henderson R. 2007. Platform Owner Entry and Innovation in Complementary Markets: Evidence from Intel. *Journal of Economics & Management Strategy* **16**(1): 1-34.

Gioia DA, Corley KG, Hamilton AL. 2013. Seeking Qualitative Rigor in Inductive Research:Notes on the Gioia Methodology. **16**(1): 15-31.

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

Gomes LAdV, Facin ALF, Salerno MS, Ikenami RK. 2018. Unpacking the innovation ecosystem construct: Evolution, gaps and trends. *Technological Forecasting and Social Change* **136**: 30-48.

Govindarajan V, Trimble C. 2005. Building breakthrough businesses within established organizations, HARVARD BUSINESS SCHOOL PUBLISHING CORPORATION: WATERTOWN.

Greenblatt JB, Saxena S. 2015. Autonomous taxis could greatly reduce greenhouse-gas emissions of US light-duty vehicles. *Nature Clim. Change* **5**(9): 860-863.

Guba EG, Lincoln YS. 1982. Epistemological and methodological bases of naturalistic inquiry. *ECTJ* **30**(4): 233-252.

Hadar E, Silberman GM. Year. Agile architecture methodology: long term strategy interleaved with short term tactics. In Proceedings of the Companion to the 23rd ACM SIGPLAN conference on Object-oriented programming systems languages and applications.

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

Jacobides MG, Cennamo C, Gawer AJSMJ. 2018. Towards a theory of ecosystems.

Johnson RB. 1997. Examining the validity structure of qualitative research. *Education* **118**(2): 282.

Kawulich BB. Year. Participant observation as a data collection method. In Proceedings of the Forum Qualitative Sozialforschung/Forum: Qualitative Social Research.

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

Latzer M. 2009. Information and communication technology innovations: radical and disruptive? *New Media & Society* **11**(4): 599-619.

Lawson B, Samson D. 2001. DEVELOPING INNOVATION CAPABILITY IN ORGANISATIONS: A DYNAMIC CAPABILITIES APPROACH. *International Journal of Innovation Management* **5**(3): 377-400.

Lee C, Lee K, Pennings JM. 2001. Internal capabilities, external networks, and performance: a study on technology-based ventures. **22**(6-7): 615-640.

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).

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

Madhok A, Tallman SB. 1998. Resources, Transactions and Rents: Managing Value Through Interfirm Collaborative Relationships. **9**(3): 326-339.

Maxwell JA. 2012. *Qualitative research design: An interactive approach*. Sage publications.

Moe NB, Aurum A, Dybå TJI, Technology S. 2012. Challenges of shared decision-making: A multiple case study of agile software development. **54**(8): 853-865.

Mondragon CEC, Mondragon AEC, Miller R. 2007. Modularity, open architecture and innovation: an automotive perspective. *International Journal of Automotive Technology and Management* **6**(3): 346-363.

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

Mulhall A. 2003. In the field: notes on observation in qualitative research. *Journal of Advanced Nursing* **41**(3): 306-313.

Nelson RR, Sidney G. 2005. Winter. 1982. An evolutionary theory of economic change, Cambridge, MA: Harvard University Press.

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

Oh DS, Phillips F, Park S, Lee E. 2016. Innovation ecosystems: A critical examination. *TECHNOVATION* **54**: 1-6.

Pelliccione P, Knauss E, Heldal R, Magnus Ågren S, Mallozzi P, Alminger A, Borgentun D. 2017. Automotive Architecture Framework: The experience of Volvo Cars. *Journal of Systems Architecture* **77**: 83-100.

Peltoniemi M. Year. Cluster, value network and business ecosystem: Knowledge and innovation approach. In Proceedings of 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.

Pinch TJ, Bijker WE. 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**.

Pinto JK, Prescott JE. 1990. Planning and tactical factors in the project implementation process. **27**(3): 305-327.

Porter ME. 1980. Competitive strategy: Techniques for analyzing industries and competition. *New York* **300**.

Pretschner A, Salzmann C, Schatz B, Stauner T. Year. 4th international ICSE workshop on software engineering for automotive systems. In Proceedings of the Software Engineering-Companion, 2007. ICSE 2007 Companion. 29th International Conference on.

Rigby DK, Sutherland J, Takeuchi H. 2016. Embracing agile. *Harvard Business Review* **94**(5): 40-50.

Rohrbeck R, Hölzle K, Gemünden HG. 2009. Opening up for competitive advantage – How Deutsche Telekom creates an open innovation ecosystem. *R&D Management* **39**(4): 420-430.

Saunders ML, Lewis P. 2009. P. and Thornhill, A.(2009). *Research methods for business students* **4**.

Scaringella L, Radziwon A. 2018. Innovation, entrepreneurial, knowledge, and business ecosystems: Old wine in new bottles? *Technological Forecasting and Social Change* **136**: 59-87.

Schultz RL, Slevin DP, Pinto JK. 1987. Strategy and Tactics in a Process Model of Project Implementation. **17**(3): 34-46.

Schumpeter J. 1942. Creative destruction. *Capitalism, socialism and democracy* **825**.

Siggelkow N. 2007. Persuasion with case studies. *Academy of management journal* **50**(1): 20-24.

Slevin DP, Pinto JKJSmr. 1987. Balancing strategy and tactics in project implementation. **29**(1): 33-41.

Suárez FF, Utterback JM. 1995. Dominant Designs and the Survival of Firms. *Strategic Management Journal* **16**(6): 415-430.

Teece D, Pisano G. 1994. The dynamic capabilities of firms: An introduction. *Industrial and Corporate Change* **3**(3): 537-556.

Teece DJ. 1986. Profiting from technological innovation: Implications for integration, collaboration, licensing and public policy. *Research Policy* **15**(6): 285-305.

Teece DJ. 2007. Explicating dynamic capabilities: the nature and microfoundations of (sustainable) enterprise performance. *Strategic management journal* **28**(13): 1319-1350.

Teece DJ, Pisano G, Shuen A. 1997. Dynamic Capabilities and Strategic Management. *Strategic Management Journal* **18**(7): 509-533.

Thomopoulos N, Givoni M. 2015. The autonomous car—a blessing or a curse for the future of low carbon mobility? An exploration of likely vs. desirable outcomes. *European Journal of Futures Research* **3**(1): 14.

Townsend JD, Calantone RJ. 2014. Evolution and Transformation of Innovation in the Global Automotive Industry. *Journal of Product Innovation Management* **31**(1): 4-7.

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.

Tripsas M. 2009. Technology, Identity, and Inertia Through the Lens of "The Digital Photography Company". *Organization Science* **20**(2): 441-460.

Utterback J. 2004. The dynamics of innovation. *Educause review* **39**: 42-51.

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

Van de Ven AH, Huber GP. 1990. Longitudinal field research methods for studying processes of organizational change. *Organization science* **1**(3): 213-219.

Vecchiato R. 2017. Disruptive innovation, managerial cognition, and technology competition outcomes. *Technological Forecasting and Social Change* **116**: 116-128.

Verna A. 2008. Value network analysis and value conversion of tangible and intangible assets. *Journal of Intellectual Capital* **9**(1): 5-24.

Victor T, Rothoff M, Coelingh E, Ödblom A, Burgdorf K. 2017. When Autonomous Vehicles Are Introduced on a Larger Scale in the Road Transport System: The Drive Me Project. In *Automated Driving: Safer and More Efficient Future Driving.* Watzenig D, Horn M (eds.), Springer International Publishing: Cham.

VolvoCars. 2016. Volvo Cars and Uber join forces to develop autonomous driving cars. https://www.media.volvocars.com/global/en-gb/media/pressreleases/194795/volvo-cars-and-uber-join-forces-to-develop-autonomous-driving-cars (14 May 2019).

VolvoCars. 2017a. Volvo cars and Autoliv autonomous driving joint venture zenuity starts operations. https://www.media.volvocars.com/global/en-gb/media/pressreleases/207309/volvo-cars-and-autoliv-autonomous-driving-joint-venture-zenuity-starts-operations (March 17 2019).

VolvoCars. 2017b. Volvo Cars to supply tens of thousands of autonomous drive compatible cars to Uber. https://www.media.volvocars.com/global/en-gb/media/pressreleases/216738/volvo-cars-to-supply-tens-of-thousands-of-autonomous-drive-compatible-cars-to-uber (14 May 2019).

VolvoCars. 2019. The Future of Driving | Volvo Cars. https://www.volvocars.com/intl/buy/the-future-of-driving (14 May 2019).

Williamson PJ, De Meyer A. 2012. Ecosystem Advantage: How to Successfully Harness the Power of Partners. *California Management Review* **55**(1): 24-46.

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.

Yin RK. 2009. *Case study research: design and methods*. SAGE: London.

Zenuity. 2018. Make it real – Zenuity. https://www.zenuity.com/make-it-real/#our-mission.

Zhang Y, Li H, Hitt MA, 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.

Paper I

Pushpananthan G. and Elmquist M., Lindlöf L. (2018). The transformation of the automotive firm in the age of automation – Early findings from a case study of the Drive Me project at Volvo Cars, *EURAM conference, June 19-22, 2018, Reykjavik, Iceland*.

The transformation of the automotive firm in the age of automation– early findings from a case study of the Drive Me Project at Volvo Cars

Abstract

A firm's ability to innovate is central to establishing competitive advantage. Innovation shapes the industries and determines the future of firms. In today's competitive environment, organizations are striving to build organizational capabilities to engage in discontinuous innovation. In recent times, due to advances in communication systems, sensor technology, artificial intelligence etc., automotive firms are increasingly engaging in open and collaborative value networks. This is a new way of structuring innovation for incumbents in traditional industries as they are entrenched in value chain mode of operations. Due to the complexity of technologies behind autonomous cars, incumbent automotive firms have increasingly opened up their innovation process to collaborate with other actors ranging from suppliers to customers and even competitors.

Keywords: Value networks, Organizational change, Open innovation, Organizational capabilities

Introduction

As organizations evolve over centuries, new postulations and theories on managerial functions in organizations evolve (Gulati, Puranam, & Tushman, 2012). In recent times, firms have increasingly opened up their innovation processes to collaborate with other actors, ranging from suppliers to customers and even competitors (Chesbrough, 2012). Over the past two decades, the complexity in technical development projects has led to an increase in the frequency of inter-firm collaborations. The developments in digital technologies have environmental, social and human consequences that go far beyond the immediate purpose of the technical devices (boyd & Crawford, 2012). One example is the availability of internet at affordable price creating farther reaching social consequences than the technology per se, altering human behaviour beyond spatialities and temporalities (boyd & Crawford, 2012).

These advancements in digital technology has enabled and spurred partnerships across geographies, industries and firm or industry specific value chains. Value chain thinking has been the most useful way to understand the functioning of traditional industries churning out physical products (Allee, 2000). The concept of value chain is useful to understand the linkage of activities within an industry (Peppard & Rylander, 2006). However, mature industries in recent times are increasingly operating in value networks to access the knowledge bases outside the industry boundary. Thus, the concept of value chain is becoming redundant due to the digitalization of products and services (Peppard & Rylander, 2006).

The automotive industry is a driver for economic progress and the development of the industry echoes the advancement(s) in the modern world as vehicles encompass a multitude of components and materials. The industry leverages on every major technology ranging from mining to semiconductors. Currently, the automotive industry is witnessing an increasing R&D activity due to the growing interest in *electrification, connectivity* and *autonomous drive*. The rapid advancements in software and sensor technologies, have led to a rapid increase in interactions across traditional industry boundaries. Autonomous drive (AD), in particular, has the potential to transform the entire automotive industry and much of today’s transport infrastructure (Lee, Gerla, Pau, Lee, & Lim, 2016).

Historically, the automotive industry has been a text book example of the value chain model around the Original Equipment Manufacturer (OEM), but increasingly value is now created outside the value chain (Paquin & Howard-Grenville, 2013). In a collaborative innovation set up, value is created in networks where all actors play a vital role in creating and delivering value (Peppard & Rylander, 2006).

The AD technology is mainly developed outside the OEM's value chain and the established firms need to interact with actors outside the industry to capture the competences required to compete in the future. Although this is new to the automotive industry, similar patterns have been observed in other industries where hardware and software technologies have converged due to advancements in internet and communication technologies (ICT), sensor systems, machine learning and artificial intelligence. For instance, developments in the smartphone industry, has shown that incumbent giants (such as Nokia, Blackberry and Motorola) can be dethroned by new players (such as Apple, Google and Samsung). The future of the automotive industry is still uncertain, but it is beyond doubt that the automation will transform the whole industry, as cars transform into a data driven product. This means that the development of autonomous vehicles will definitely differ from that of traditional car development projects. But, we still know little about how the automotive firms tackle the challenges that this change brings about. Therefore, the objective of this paper is *to explore the main challenges of automotive firms face in the transition to autonomous vehicles.* It will address two main research questions

- What are the main differences in an autonomous vehicle project compared to a traditional car development project?

- What are the main challenges that automotive firms face in the transition to autonomous drive?

This paper is based on a longitudinal, exploratory study of Volvo Cars' autonomous car project "Drive Me". Initial findings indicate that the project is not only based on radically new technology for a completely new market, the organizational set up required by the project has also required radical changes in the way the automotive firms works.

Innovation, value networks and organizational capabilities

Innovation is the most sought-after activity by firms in order to sustain their competitive advantage. The knowledge economy and rapid strides in technology has reiterated the urgency and need for innovation as it is central to firm competitiveness (Lawson & Samson, 2001). Yet, very few large firms have been successful in carrying out innovation that is radical in nature. Non-incremental innovation, considered to be quintessential for long term survival, has often been a conundrum for large firms. Over the past decade, start-ups have been successful at challenging large established firms in ways that has been never seen before (Latzer, 2009). Schumpeter hypothesized that innovation activity is promoted by large firms and by imperfect competition (Schumpeter, 1942). However, subsequent research has shown that large firms are not necessarily more innovative than their smaller counterparts (Acs & Audretsch, 1987).

In today's competitive environment, leaders and managers are driving to build organizational capabilities to engage in innovative endeavors (Teece & Pisano, 1994). During the 1980s and 1990s, high quality and value-added imports were threating the dominance of western industries in areas such as electrical, automotive and semiconductors (Lawson & Samson, 2001). Competitive advantage during these times were built around efficiency, customer responsiveness, quality and speed. Today, these variables represent the minimum threshold to compete. The need to innovate – not just occasional or incremental – but systematic, continuous and radical innovation with a solid success rate is quintessential for survival (Lawson & Samson, 2001).

In order to possess sustained competitive advantage, firms need to constantly match their internal capabilities with dynamic external environment (Nelson Richard & Winter Sidney, 1982; Nelson & Winter, 1974; Penrose, 1959; Teece & Pisano, 1994). Knowledge, skills, experiences embedded in a firm are crucial to generate and sustain competitive advantage. Penrose (1959) argued that a firm's physical resources or tangible assets and human resources or intangible assets are important pillars for success. The resource based theory explains the firm's ability to explore, experiment and innovate with its resources to provide new offerings in the market (Davies & Brady, 2000). In order to carry out activities such as design, R&D, production, marketing etc. firms must develop and retain capabilities in the form of organization routines, skills, knowledge, experience (Davies & Brady, 2000; Richardson, 1972).

However, organization's capabilities that are embedded in its routines and procedures are not the most valuable when faced with changing environment (Nelson Richard & Winter Sidney, 1982). However, capabilities of a firm that are considered to be central to the firm's competitiveness can become 'core rigidities' or 'organizational inertia' in times of rapid technological change or entering new markets (Leonard 1995, (Iansiti, 1998). Thus, in order to adapt to changing business requirements, firms need to possess capabilities dubbed as 'absorptive capacity' (Davies & Brady, 2000). The absorptive capacity enables a firm to capture new knowledge, resources and utilize them to compete in new environments. Firms that do not assimilate new knowledge or competences may forfeit the ability to compete in the future. Thus, firms are increasingly pushed to reply on collaborations and partnerships to execute innovation projects despite significant transaction costs associated with such practices (Gulati et al., 2012). Also, the absorptive capacity should also enable a firm to change the way it operates, managers and engages in innovation projects. In recent times, we see firms moving out of their value chain in order to create value in a collaborative network that transpires industry boundary. Internet and related technologies have become enablers for new forms of knowledge creation and dissemination (Gulati et al., 2012). Thus, actors beyond traditional boundaries of a firm are able to work closely within the firm (Chesbrough, 2003; Gulati et al., 2012).

In today's knowledge economy, creation of a superior product spreads beyond the boundaries of the lead firm (Linden, Kraemer, & Dedrick, 2009). A value network extends beyond just transactions around goods, services, and revenue wherein the strength of the value network exists in the interactions between the actors (Peltoniemi, 2004). It enables exchange of tacit and explicit knowledge, technical know-how, policy development, process and product knowledge etc. In a value network, a clear understanding of the expectations by each network member is crucial (Peppard & Rylander, 2006). According to 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". The participants of a value network can be identified from the standpoint of the focal firm, wherein all actors who influence the value delivered by the focal firm to the end-customer are active members of the value network. Networks can have a multitude of meanings and definition. Value network is perhaps a way to envisage how value is created by multiple firms working together. This set up where multiple firms or actors collaborate together to develop value is often referred to as the innovation ecosystem.

Firms are exploring new ways to access knowledge beyond their traditional way. New knowledge created by individuals need to be amplified and accentuated by the organization (Elmquist, Ollila, & Yström, 2016b). However, works on open innovation often focus the innovation intermediaries without impetus on the knowledge generation attributes within an organization (Nonaka & Takeuchi, 1995). There is an increase in collaborations between independent firms requiring a rethinking about organization design. There have several works done in recent times to rethink the way organizations create value. Some of the prominent ones gaining attention have been based on open innovation, innovation ecosystem, innovation network etc. All these theories and concepts are useful to analyze collaborations between firms across industry or regional boundaries (Elmquist, Ollila, & Yström, 2016a). Thus, these theories and concepts support the understanding of the interactions between various actors value network where actors make choices on what and with whom to transact depending on the strategic objective, knowledge requirements and innovation goals (Paquin & Howard-Grenville, 2013).

Thus, the era of big data has shifted the way firms create and capture value. In today's digital world, firms are clamouring for access to massive quantities of information produced by and about people (boyd & Crawford, 2012). The quest to access and hoard data comes from the benefits of large scale data to help firms build better tools, services and public goods.

The transformation of the automotive industry

A time of transformation

Railroads in the 19th century provided efficient and cheap transportation and transformed the competitive landscape by enabling firms to reach far beyond their home regions and compete with rival across vast geographies (Garud, Kumaraswamy, & Langlois, 2009). The railroads altered management practices to deal with the complexity of high fixed costs of infrastructure and new ways of engaging in business across distant geographies. This transformation set the foundation for the second industrial revolutions in the 20th century. Likewise, the increasing engagement of automotive firms outside the traditional value chain into value networks ushers in new management practices and routines in order to support the collaborative innovation endeavours.

The automotive industry is currently witnessing a transition from mechanical products to data driven products. In 1981, GM used a microprocessor-based control system in their cars that executed 50,000 lines of code (Lee et al., 2016). This can be contrasted to today's high-end cars, where it takes a few hundred million lines of code to get a car out of the garage. The software in modern cars execute hundreds of microprocessor-based control units. The automobiles of the future are no longer a simple interface consisting of battery, alternator, carburettor etc., but they are an amalgamation of software, microprocessors, electronic sensors along with mechanical parts.

The era of big data has shifted the way firms create and capture value. In today's digital world, firms are clamouring for access to massive quantities of information produced by and about people (boyd & Crawford, 2012). The quest to access and hoard data comes from the benefits of large scale data to help firms build better tools, services and products. The adoption of one technology over another pave the way for economies of scale, network externalities and increasing returns. Traditional markets are rapidly replaced by networks with increasing interdependence and collaboration between actors thereby requiring a shift in the organizational practices and inter-organizational relationships (Aarikka-Stenroos & Ritala, 2017). In recent times, the value network way of analysing innovation activity has gained prominence (Adner & Kapoor, 2010; Gawer & Cusumano, 2014; Moore, 1993). Just like the railroads altered the management practices in the 19th century, the cars of the future require new organizational routines and practices from the incumbent automotive firms. In order to understand the impact of technology on an industry, it is also relevant to investigate the progress around a core technology including managerial, societal and business aspects.

Mass production Vs efficiency – Nature of competition in automotive industry

During the periods prior to World war II and up to the late 50s, U.S. and European auto makers insisted on mass production with minimal product variation in order to lower costs (Cusumano, 1988). This meant that American manufacturers often attained high volumes that required storage of produced goods for many months. Also, the U.S. and European car makers preferred workers and equipment specialization meaning that the production plants and workforce were trained to do specific tasks or routines in order to improve efficiency. This inadvertently led to the 'push-system' wherein the need to keep workers and machines active led to enlarged inventories. This push concept meant that the firms tested only a few samples from a batch leading to a lot of defective components slipping through to the next stage.

In contrast to the American firms, during the 1970s, the Japanese automotive firms made tremendous indents into the global automotive industry by developing high efficiency in the manufacturing processes (Cusumano, 1988). They essentially displayed that mass production by reducing diversity of products in order to reach economies of scale pioneered by the US automotive firms is not the only way to attain dominance in the automotive industry. Since the Japanese automakers did not have the volumes like their American and European counterparts, they adopted flexibility in their manufacturing system. Pioneered by Toyota before the 1950s and followed suit by other Japanese firms, equipment and personnel were used for different models and components in order to get rid of under-utilized equipment and workers (Cusumano, 1988). This ensured that Japanese automakers attained higher levels of productivity and small batches allowed for more rigorous testing of components leading to minimized risk of defective components.

Thus, Contrary to the American push-system, Toyota's Executive president Taiichi Ohno pioneered the 'pull system' that reduces inventories by churning out components at just the appropriate time. Moving away from the American trend of vertical integration and specialized machinery and workforce, the Japanese firms tripled their productivity between the 1960 and 1980 (Cusumano, 1988). This superior performance meant that the Japanese automotive firms achieved high levels of productivity and superior processes in an industry synonymous with mass production and manufacturing efficiency as a sustainable competitive advantage (Cusumano, 1988). The industry has historically focused on economies of scale, lowering cost and increasing productivity. However, the current trends in the industry indicate that the innovation trajectory is shifting towards software and electronic technologies.

Value networks in the automotive industry

The motor vehicles are transforming at a rapid rate with increasing complexity that is beyond the competences and resources within the automotive firm's value network (Mondragon,

Mondragon, & Miller, 2007). The automotive industry is at the ideal milieu to transition into an industry synonymous with open architectures as a way to leverage their hardware competences and couple them with ever-growing demand for better software and connected solutions for motor vehicles. New environmental regulations in developed nations and changes in customer preferences add further complexity to the innovation efforts of automotive firms. Also, the technology and product life cycles are becoming shorter due to rapid advancements in digital technology. In order to grapple with this seismic shift, automotive firms need to develop new strategies to stay competitive and innovate in an ever-shifting landscape. The magnitude of digital interfaces in modern cars are increasing exponentially (Pretschner et al., 2007). It was estimated that by 2010, a top segment vehicle would encompass one gigabyte of software which is equivalent to a standard desktop and this trend would continue to increase over the years. Also, in mature markets, customers expect more out of the car for the same price which translates into new functional demands and the lowering cost of communication hardware has become an enabler for advanced electronic systems. Such electronics in cars also increase safety, fuel efficiency and comfort (Pretschner et al., 2007). Thus, the automotive industry is witnessing rapid changes in term of both technology and market trends. However, the industry has not been operating in this fashion few decades ago as the focus had been on improving manufacturing efficiency and reaching economies of scale.

For a long time, the automotive industry has been dominated by a few original equipment manufacturers (OEMs). The vehicle has long been an extension of man's mobility system subordinate to the commands of the man (Lee et al., 2016). The industry traditionally has focused its R&D efforts on material science, mechanics, electronics and industrial engineering focusing on pushing the performance of the Internal Combustion (IC) engine

(Mondragon et al., 2007). However, with rapid advances in communication, sensor systems and cloud infrastructure, the industry is facing an increasing complexity, beyond the competences and resources within the OEMs' current value chain (Lee et al., 2016). The huge costs involved with complex product innovation has pushed major players to collaborate in value networks in order to access complementary assets, technological expertise or specialized knowledge bases outside individual firm (Johansson, Axelson, Enberg, & Tell, 2011). Today, the vehicle is transforming into a platform that is capable of autonomous navigation and decision making. 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.

Method

This chapter provides a description of the research approach, research design and the methods employed to address the aforementioned research questions.

Research approach and research design

This paper is based on a longitudinal case study of Volvo Cars' autonomous car project "Drive Me". The aim of the Drive Me project is to develop autonomous drive technology and understand the effects of autonomous cars on environment, infrastructure, traffic safety etc. Due to the inherent complexity in developing autonomous car, Volvo Cars set up the Drive Me project as a collaboration involves several partners, including the Swedish road authority, local universities and research institutes. (Volvo Cars, 2017 A).

The case study aims to explore how incumbent firms collaborate on a project level with multiple actors. The study began in October 2016 and is planned to continue for two years. It explores how an incumbent firm, such as Volvo Cars, evolve and collaborate on a project level with multiple actors in an innovation network. The study tracked changes and transformations that happen within the Drive Me project at Volvo Cars. Over the past year, the study has generated rich empirical data. The case study design was chosen since the studied phenomenon is evolving within a real-life context (Eisenhardt & Graebner, 2007; Hobday & Rush, 1999; Yin, 2009)

Due to the nature of the case being emergent and unique, the empirical data and theory are concurrently revisited to better understand the context. By moving back and forth between the empirical setting and theory, the study follows the systematic combining approach (Dubois & Gadde, 2002). The case study uses empirical data along with secondary data on current trends and market shifts in the automotive industry to support the empirical observations. As the study was intended to be exploratory in nature, a single case design was deemed appropriate as it enables to look in-depth at one or small number of events (Easterby-Smith, Thorpe, & Jackson, 2012).

Data collection and analysis

The data was collected in the form of open and semi-structured interviews. Field notes were used to record the data from observations. The purpose of the field notes is to understand the project context, identify relevant stakeholders and also frame with interview questions. The interviews and observation data were collected over a period of 12 months. Approximately 7 managers involved in the autonomous cars project were interviewed. However, due to the nature of the interviews being open, interviews that were deemed relevant for the scope of this paper were chosen for the data analysis. The intention is to use nVivo coding software for the analysis once the study is completed, but so far initial analysis has been made through thematic analysis primarily. The aim for the future is to increase the rigour of the data analysis by incorporating field notes and more interview data to support the findings and observations. This will both increase the trustworthiness and generalizability of the findings.

Empirical context – Volvo Cars and the Drive Me project

This chapter provides a brief overview of the Drive Me project at Volvo Cars and its current trends. Further, information on the case firm Volvo Cars and the Drive Me project is presented to better understand the empirical context.

Volvo Cars is a Gothenburg based car company with manufacturing hubs in Sweden, Belgium and China. Since the 1920s, Volvo has pioneered several world-changing innovations such as the three-point safety belt, rearward-facing child safety seat, city safety, connected safety etc. (Volvo Cars, 2014). Today, as an established car manufacturer, Volvo Cars is spearheading the development of autonomous drive technology. To this effect, Volvo Cars has initiated collaborations across the world in order to be at the forefront of autonomous drive technology (Volvo Cars, 2015). As an incumbent in the automotive industry, Volvo Cars is used to collaborating with other OEMs and suppliers in the industry. However, the nature of collaborations today is very different. Due to the extent of technologies involved in developing autonomous cars, Volvo is engaging with actors outside the automotive industry.

Due to the inherent complexity in developing autonomous car, Volvo Cars set up the Drive Me project (Volvo Cars, 2017 A). The aim of the Drive Me project is to develop autonomous drive technology and understand the effects of autonomous cars on environment, infrastructure, traffic safety etc. The project involves development, testing and verification of the autonomous drive technology in order to facilitate the transformation from supervised to unsupervised driving. The software development is handled by Zenuity, a new entrant in the industry created as a joint venture between Volvo Cars and Autoliv (Volvo Cars, 2017 B). Both Volvo and Autoliv have transferred their intellectual property on 'Advanced Driver Assistance Systems' (ADAS), know-how and personnel to the joint venture firm 'Zenuity' (Volvo Cars, 2017 B). Apart from Zenuity, several other actors such as Chalmers University, Autoliv, City of Gothenburg, Lindholmen Science Park etc. are involved in the Drive Me project. Thus, much of the innovation activity in developing autonomous cars is taking place outside of Volvo Cars in a collaborative set up.

Empirical findings

The early phase of the case study was predominantly centred around understanding the project context and identifying relevant stakeholders. The interviews were carried out in order to understand the purpose of Drive Me project and why Volvo Cars set up Zenuity. This section has important excerpts from the data collection process which will be further used in the discussion chapter.

Why the Drive Me project?

The reasons why Volvo Cars decided to set up the Drive Me projects are manifold. Most interviewees expressed that the complexity in developing the autonomous drive technology requires a new way of organizing innovation activities. The project has multiple purposes including studying customer behaviour, validate safety, push for legislation in order to better understand and refine the autonomous drive (AD) technology. Also, in order to achieve speed and efficiency, Volvo Cars decided to create Zenuity as a separate firm to spearhead the software development for autonomous cars – in the form of a Joint Venture owned 50 % by Volvo Cars and 50% by Autoliv (a leading safety systems supplier) . Another major reasoning behind the establishment of the Drive Me project is to build trust amongst potential customers and to be able to validate safety aspects related to autonomous driving.

The AD pilot where customer get to use a semi-autonomous car under real traffic condition as part of the Drive Me project is used to understand the safety perspective of AD and know how customers behave in an autonomous car. This entails that Volvo needs to work closely with not just suppliers but also customers, government agencies, traffic authorities etc. to an extent that is higher than previous car development projects.

What is different in the Drive Me project?

The Drive Me project has a lead supplier in the form of Zenuity. Although Volvo Cars is the focal actor in the Drive Me project, a large part of the software development is entrusted upon Zenuity. Also, compared to other car development projects where building the car is the primary objective, the Drive Me project's main purpose is to develop software and sensor sets as an early step in the move towards a completely autonomous drive technology in the future. In order to achieve this, Volvo Cars engages with several actors outside the value chain. Thus, the innovation activity in the Drive Me project is outside the traditional value chain of Volvo Cars which is in stark contrast to previous such innovation projects.

This is further exemplified from the following quote below,

> *If you look at the car industry today, we do not own our value chain…. what we see for the future, the value chain management will change. Locked together with AD but also with electrification and fleet* (Manager, Volvo Cars, interview)

Thus, Volvo Cars needs to transition from hardware development into software development which poses significant challenges as incumbent firms in an established industry have a water fall way of working. On the other hand, Zenuity has introduced an agile way of working synonymous with the ways of working in the software industry. In order to efficiently collaborate, co-create and coordinate the development activities, Volvo Cars need to rethink the established organizational routines, in line with theories on organizational change.

Implications for Volvo Cars

One of the constraints while engaging in a collaborative network to develop autonomous cars is that firms from mature industries such as the automotive industry often have a waterfall way of working that creates a mismatch between the automotive firm and its collaborators who are largely software and electronic firms. The Drive Me project at Volvo Cars is set up in a way that lets Volvo Cars, as an incumbent automotive firm, to leverage the capabilities of a range of external actors. However, such shift of innovation practices needs to be coupled with new organizational routines that permits innovation outside the traditional value chain of Volvo Cars.

The Drive Me project, due to its inherent complexity and range of actors involved, is ushering in a change in new management practices when it comes to engaging with suppliers and other actors. The traditional waterfall way of working is being replaced by agile working methods. However, this transformation is not fully in place as routines and practices that have been in place for many decades transform in core rigidities (Perez-freije & Enkel, 2007). Thus, the biggest challenge in such organizational level transformation is the culture as one interview said, *One of the core rigidity we really have is the culture. Norms, values and culture (*Manager, Volvo Cars, interview)

Since the future of the automotive industry is heading towards electrification, connectivity and autonomous drive, the organizational practices of the Drive Me project needs to permeate throughout the entire firm in order to enhance Volvo Cars' future innovation success.

Conclusions and implications

Concluding discussion

This paper set out to identify the main challenges that automotive firms face in the transition to autonomous vehicles. Initial findings indicate the challenges include – but not limited to – rethinking traditional management practices that are deeply entrenched in the firm. The autonomous drive technology development is highly depending on big data and deep learning. Today, cars increasingly look more like computers and less like cars (Lee et al., 2016). Many interviews expressed that there is a need to change the way of working in order to adapt to a fast changing industry landscape.

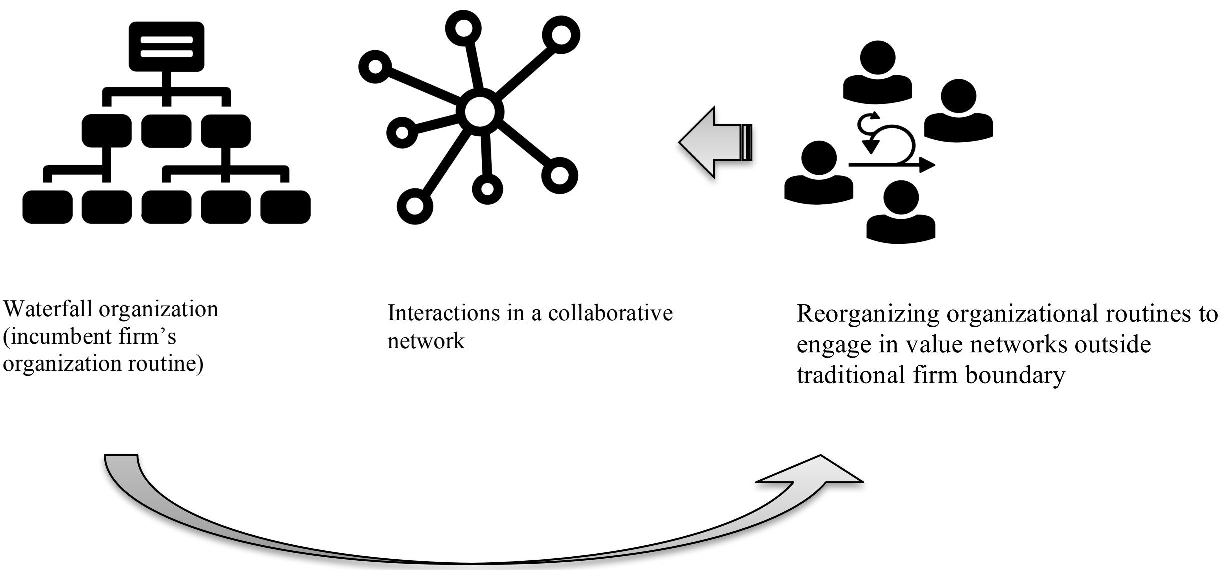

Figure 1. Transformation within the Drive Me project to engage in value network outside firm boundary

With the advancements in internet and communication technologies (ICT), the impetus on the physical dimension of the value chain is losing its relevance in modern industries (Verna, 2008). The traditional methods of analyzing competitive advantage (Porter, 1980) and organizational routines need to be revisited due to the emergence of the network economy. As in the case of car industry, through the empirical evidences from Volvo's autonomous car project, it is increasingly evident that product development is becoming data driven (boyd & Crawford, 2012). Thus, automotive firms need to change old organizational routines in the era of autonomous car as product development is increasingly software dependent than ever before. As shown in figure 1, Volvo Cars especially within the Drive Me project is persevering to alter the management practices that enable more agile and iterative product development. However, such transformations have several challenges including changing practices that are well entrenched in the corporate system, problems associated with synchronizing agile development at the Drive Me project with other departments and interfaces in the firm. Also, another significant challenge that was identified through the case study was the uncertainty surrounding self-driving cars in terms of technology, legislation, customer preference, dominant design etc.

Limitations and further research

The study is still in early phase due to the longitudinal design of the case study and this paper is only an early draft. Thus, more data in the form of interviews and field observation will provide a better clarity on how Volvo Cars handles the transformation from a traditional waterfall organization to an agile organization, at least in the case of the Drive Me project. This paper does not cover all data collected the rich empirical data collected over the past 12 months requires more systematic data analysis, a work that is ongoing. Thus, the immediate next step is to perform more analysis to increase the quality of the research findings. Further, the study continues to follow the Drive Me project to see how Volvo Cars handles the numerous challenges related to developing the autonomous cars. Since the product development is expected to last several years, it is important to collect more empirical data that will enable us to contribute towards the field of organization change in order to cope with the digital transformation that is rampant across all mature industries.

References:

Aarikka-Stenroos, L., & Ritala, P. (2017). Network management in the era of ecosystems: Systematic review and management framework. Industrial Marketing Management, Vol. 67, No. Supplement C, pp. 23-36. doi:https://doi.org/10.1016/j.indmarman.2017.08.010

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, Vol. 31, No. 3, pp. 306-333.

Allee, V. (2000). Reconfiguring the value network. Journal of Business strategy, Vol. 21, No. 4, pp. 36-39.

boyd, d., & Crawford, K. (2012). CRITICAL QUESTIONS FOR BIG DATA. Information, Communication & Society, Vol. 15, No. 5, pp. 662-679. doi:10.1080/1369118X.2012.678878

Chesbrough, H. (2003). Open innovation. In: Boston: Harvard Business School Press.

Chesbrough, H. (2012). Open Innovation: Where We've Been and Where We're Going. Research-Technology Management, Vol. 55, No. 4, pp. 20-27. doi:10.5437/08956308X5504085

Cusumano, M. A. (1988). Manufacturing Innovation: Lessons From The Japanese Auto Industry. Sloan Management Review, Vol. 30, No. 1, pp. 29.

Davies, A., & Brady, T. (2000). Organisational capabilities and learning in complex product systems: towards repeatable solutions. Research Policy, Vol. 29, No. 7, pp. 931-953. doi:10.1016/S0048-7333(00)00113-X

Dubois, A., & Gadde, L.-E. (2002). Systematic combining: an abductive approach to case research. Journal of Business Research, Vol. 55, No. 7, pp. 553-560. doi:10.1016/S0148-2963(00)00195-8

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

Eisenhardt, K. M., & Graebner, M. E. (2007). Theory Building from Cases: Opportunities and Challenges. The Academy of Management Journal, Vol. 50, No. 1, pp. 25-32. doi:10.2307/20159839

Elmquist, M., Ollila, S., & Yström, A. (2016a). Beyond intermediation: The open innovation arena as an actor enabling joint knowledge creation (Vol. 72).

Elmquist, M., Ollila, S., & Yström, A. (2016b). Beyond intermediation: the open innovation arena as an actor enabling joint knowledge creation. International Journal of Technology Management, Vol. 72, No. 4, pp. 273-295.

Garud, R., Kumaraswamy, A., & Langlois, R. (2009). Managing in the modular age: architectures, networks, and organizations: John Wiley & Sons.

Gawer, A., & Cusumano, M. A. (2014). Industry Platforms and Ecosystem Innovation: Platforms and Innovation. Journal of Product Innovation Management, Vol. 31, No. 3, pp. 417-433. doi:10.1111/jpim.12105

Gulati, R., Puranam, P., & Tushman, M. (2012). Meta-organization design: Rethinking design in interorganizational and community contexts. Strategic Management Journal, Vol. 33, No. 6, pp. 571-586. doi:10.1002/smj.1975

Hobday, M., & Rush, H. (1999). Technology management in complex product systems (CoPS) - ten questions answered. International Journal of Technology Management, Vol. 17, No. 6, pp. 618-638. doi:10.1504/IJTM.1999.002739

Iansiti, M. (1998). Technology integration: making critical choices in a dynamic world. Boston, Mass: Harvard Business School.

Johansson, M., Axelson, M., Enberg, C., & Tell, F. (2011). Knowledge Integration in Inter-firm R&D Collaboration: How do Firms Manage Problems of Coordination and Cooperation. Knowledge Integration & Innovation–Critical Challenges Facing International Technology-based Firms, Vol., No., pp. 148-169.

Latzer, M. (2009). Information and communication technology innovations: radical and disruptive? New Media & Society, Vol. 11, No. 4, pp. 599-619.

Lawson, B., & Samson, D. (2001). DEVELOPING INNOVATION CAPABILITY IN ORGANISATIONS: A DYNAMIC CAPABILITIES APPROACH. International Journal of Innovation Management, Vol. 5, No. 3, pp. 377-400. doi:10.1142/S1363919601000427

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, Vol. 12, No. 9, pp. doi:10.1177/1550147716665500

Leonard-Barton, D., Books24x, & Books24x, I. (1995). Wellsprings of knowledge: building and sustaining the sources of innovation. Boston, Mass: Harvard Business School Press.

Linden, G., Kraemer, K. L., & Dedrick, J. (2009). Who captures value in a global innovation network?: the case of Apple's iPod. Commun. ACM, Vol. 52, No. 3, pp. 140-144. doi:10.1145/1467247.1467280

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, Vol. 6, No. 3, pp. 346-363. doi:10.1504/IJATM.2006.012125

Moore, J. F. (1993). Predators and prey: a new ecology of competition. Harvard business review, Vol. 71, No. 3, pp. 75-83.

Nelson Richard, R., & Winter Sidney, G. (1982). An evolutionary theory of economic change. Harvard Business School Press, Cambridge, Vol., No., pp.

Nelson, R. R., & Winter, S. G. (1974). Neoclassical vs. Evolutionary Theories of Economic Growth: Critique and Prospectus. The Economic Journal, Vol. 84, No. 336, pp. 886-905. doi:10.2307/2230572

Nonaka, I., & Takeuchi, H. (1995). The knowledge-creating company: How Japanese companies create the dynamics of innovation: Oxford university press.

Paquin, R. L., & Howard-Grenville, J. (2013). Blind dates and arranged marriages: Longitudinal processes of network orchestration. Organization Studies, Vol. 34, No. 11, pp. 1623-1653.

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.

Penrose, E. T. (1959). The theory of the growth of the firm (2nd. In: Oxford: Blackwell.

Peppard, J., & Rylander, A. (2006). From Value Chain to Value Network. European Management Journal, Vol. 24, No. 2, pp. 128-141. doi:http://dx.doi.org/10.1016/j.emj.2006.03.003

Perez-freije, J., & Enkel, E. (2007). Creative Tension in the Innovation Process. European Management Journal, Vol. 25, No. 1, pp. 11-24. doi:http://dx.doi.org/10.1016/j.emj.2006.11.005

Porter, M. E. (1980). Competitive strategy: Techniques for analyzing industries and competition. New York, Vol. 300, No., pp.

Richardson, G. B. (1972). The organisation of industry. The Economic Journal, Vol. 82, No. 327, pp. 883-896.

Schumpeter, J. (1942). Creative destruction. Capitalism, socialism and democracy, Vol. 825, No., pp.

Teece, D., & Pisano, G. (1994). The dynamic capabilities of firms: An introduction. Industrial and Corporate Change, Vol. 3, No. 3, pp. 537-556. doi:10.1093/icc/3.3.537-a

Verna, A. (2008). Value network analysis and value conversion of tangible and intangible assets. Journal of Intellectual Capital, Vol. 9, No. 1, pp. 5-24. doi:doi:10.1108/14691930810845777

Volvo Cars (2014) Safety innovation in Volvo. Retrieved November 22. 2017, at: https://www.volvocars.com/intl/about/our-company/heritage/innovations

Volvo Cars (2015) Autonomous drive in detail. Retrieved November 22, 2017, at: https://www.volvocars.com/bh/about/our-innovation-brands/intellisafe/intellisafe-autopilot/this-is-autopilot/autonomous-drive-in-detail

Volvo Cars (2017 A) Drive Me – the self-driving car in action. Retrieved November 22, 2017, at: https://www.volvocars.com/intl/about/our-innovation-brands/intellisafe/autonomous-driving/drive-me

Volvo Cars (2017 B) Volvo Cars and Autoliv autonomous driving joint venture Zenuity starts operations. Retrieved November 22, 2017, at: https://www.media.volvocars.com/global/en-gb/media/pressreleases/207309/volvo-cars-and-autoliv-autonomous-driving-joint-venture-zenuity-starts-operations

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

Paper II

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The blind leading the mute

- *Formal leaders' potential to facilitate institutionalization of the agile myth*

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ABSTRACT

More and more firms are moving from a plan-driven to an agile approach to new product development, a transition that entails significant challenges not least for managers and formal leaders. In this context we draw on institutional theory and conceptualize agile development as a myth. By considering the adoption of the agile myth in previously plan-driven product development we illustrate a paradox whereby agile development constrains the existing agility embedded in informal structures. To illustrate this, we provide an example from an ongoing ethnographic study of a product development unit currently undergoing a transition from plan-driven to agile development. We further synthesize our theoretical argument with empirical observations by presenting two distinct personas, The Blind representing the formal structure, and The Mute representing the informal structure, and draw potential from this illustration for how formal leaders can act to overcome the paradox.

Keywords: Leadership, Product development, Institutional theory, Institutional work, Agile development

Introduction

Firms engaged in the development of new products often rely on formally designed plan-driven development processes (Cooper and Sommer, 2018). Complementing such formal processes, informal structures have been recognized as indispensable to the successful development of new products (Mintzberg, 1989, Sosa et al., 2015). Agile product development emerged in part as a reaction against plan-driven formal development processes (Boehm, 2002) and can be seen as an alternative to plan-driven product development (Dingsøyr et al., 2012). Agile development has proven to be an effective and efficient approach to product development for most types of complex products (Rigby et al., 2016). In light of this, more and more firms that previously relied on plan-driven processes are now adopting agile development (Rigby et al., 2018). Agile development emerged in contexts involving no more than a handful of developers (Lindsjørn et al., 2018) primarily relying on informal communication and collaboration (Nerur and Balijepally, 2007). The scaling of agile methods that often entails the transition from plan-driven to agile development has received remarkably little scholarly attention (Dikert et al., 2016) and is in need of alternative theoretical approaches (Dingsøyr et al., 2018) and more case studies (Dikert et al., 2016).

A transition from plan-driven to agile development means a shift in focus from the formal to the informal structures in the organizing of product development efforts. The transition from plan-driven to agile development entails significant challenges (Dikert et al., 2016) and not least connected to formal leaders such as managers or project leaders (Boehm and Turner, 2005, Dikert et al., 2016). Agile development is relying on autonomous self-organizing team (Moe et al., 2009) which entails a radically different idea of leadership compared to the formally assigned leader role of plan-driven product development. Nevertheless, the increasing adoption of agile development among large industrial firms is often initiated top-down and formal leaders fostered in plan-driven development find themselves driving the change. In this context, it is therefore relevant to critically discuss what leadership is, can be and should be. In line with this, several scholars radically questions the idea of leadership as tied to a single individual (Crevani et al., 2010, Alvesson and Spicer, 2012) and instead advocate a more reflexive approach stressing a need for an ongoing dialogue about leadership in the context where it is exercised and more precisely about how it affects practice. This approach to leadership has been called critical performativity (Alvesson and Spicer, 2012).

Drawing on institutional theory agile development can be regarded as an institutional fashion among product development organizations and regarded as an institutional myth for those who have not yet adopted it (Meyer and Rowan, 1977). However, the institutionalization of myths is primarily the concern of formal structures of organizations (Brunsson, 1989) generally creating a tension between the formal and the informal structures of the organization (Seo and Creed, 2002). The informal structures are herein more focused on efficiency and effectiveness of internal operations (Brunsson, 1989). Similarly, agile development can be considered rooted in informal organizing and as a reaction against overly formalized plan-driven development processes (Boehm, 2002). The institutionalization of the agile myth into an organization where formal structures and the leaders embedded in them are set to implemented into an organization by means of formal structures entails paradox.

In this paper we outline this paradox in more detail and draw on theory of institutional work (Lawrence et al., 2013). We exemplify this paradox from an ongoing ethnographic study of a product development unit in an automotive firm that is currently moving from plan-driven to agile development. Synthesizing the theoretical outline with observations from the empirical study potentials for formal leadership to contribute in the management of this paradox is suggested.

Institutional environments and work

Organizations are not isolated from their environment, on the contrary, they can be considered as part of an environment consisting of similar and related organizations, commonly referred to as an institutional environment (Scott and Davis, 2007). For most organizations, it is not enough to demonstrate great products, but they must follow the norms of their environment in terms of structures, processes and ideologies as well (Brunsson, 1989). In this way, they are contingent on their environment, but internal action within an organization also shapes the organization's environment to some extent (Barley and Tolbert, 1997). The needs for efficiency and effectiveness in the internal operations of the organization are usually at odds with the norms of its environment (Meyer and Rowan, 1977) resulting in the emergence of two distinct structures succinctly distinguished by Nils Brunsson:

> "One is the formal organization which obeys the institutional norms and which can easily be adapted to new fashions or laws, literally by a few strokes of the pen on an organization chart. A quite different organizational structure can be used in 'reality', *i.e.* in order to coordinate action. This second type is generally referred to as the 'informal organization'." (1989:7)

Accordingly, the formal and informal organization are loosely coupled (Weick, 1976) and developed by different principles. This generates a tension between the two (Seo and Creed, 2002) by which they inevitably affect and shape one another. When new ideologies, practices and processes emerge as a new fashion in an institutional environment, not yet adopted by all organizations, Meyer and Rowan (1977) describe them as myths. They stress that unlike coordinated action that pursues efficiency and effectiveness of internal operations, a myth is not adhered to because people believe in it, but because everyone else seem to do so. Once a myth is institutionalized, it is has become part of the institutional environment and therein constitute an institution of its own. As such it can be understood as an enduring element of organizational life that have fundamental impact on the thoughts, feelings and behavior of individual and collective actors (Lawrence et al., 2009). The creation, maintenance and disruption of institutions are mediated through the deliberate practices of collective and individual actors, *i.e.* institutional work (Lawrence et al., 2011) that is motivated by the tension between the formal and the informal organization as distinguished by Brunsson (1989).

In the creation of a new institution an important type of institutional work is addressing the assignment of new meanings to existing practices (Zilber, 2002). Such institutional work is devoted to re-making the connections between sets of practices including their cultural and moral foundations, *i.e.* changing the normative associations connected to existing practices in the organization (Lawrence et al., 2009). Once meanings and practices are associated in alignment with the accommodation of the myth, the associations attain a reality like status for actors (Zilber, 2002) and the myth becomes institutionalized.

The formal organization and the origins of agile

Brunsson's (1989) notion and characterization of the formal and informal as distinct structures in organizations lends itself well for narrating an ongoing institutionalization of the agile myth in product development organizations. In this section we consider the origins of agile development and how it has related to, and been related to by formal and informal structures of product development organization over the course of its evolvement. As a backcloth for this narrative, the formal structures in relation to plan-driven development are presented (Explaining 'A' in Figure 1). Thereafter follows a description of how agile development emerged informally, in part as a critical reaction to formal structures (Indicated by 'C' in Figure 1) but how it then evolved into a myth that formal structures in product development organization are susceptible to. Finally, informal structures of plan-driven product development organization ('B' in Figure 1) are elaborated on in relation to the origins of agile development. This section is concluded by describing a paradox that this narrative builds up to when the agile myth is institutionalized (Relating primarily to 'B' and 'D' in Figure 1).

Plan-driven development and the formal organization

A structure is formal if it prescribes explicitly formulated highly specified rules and role descriptions intended to govern behavior, by which Weber's definition of a bureaucracy could be categorized as such (Scott and Davis, 2007). Formal structure can be viewed as a means for regulating behavior (Mintzberg, 1989) to make it more predictable (Scott and Davis, 2007). Corresponding to this, Petersen and Wohlin (2010) state that plan-driven development is characterized by a detailed plan with a sequential structure. According to them, plan-driven development also implies that functions, attributes and properties are specified before project start and that deviations from the detailed requirement specifications require formally managed change requests. In this way plan-driven development is similar to what (Mintzberg, 1989) describes as formalized by process and rules and can therein be considered rooted in the formal structures of product development organization (Indicated with ‘A’ in Figure 1).

With its origin in formal structures, plan-driven development still relies on the informal structures of the organization to see to the coordination of actions that provide for efficiency and effectiveness of internal operations in accordance with Brunsson’s (1989) distinction between the formal and informal. Product development organizations rely on informal structures to handle technical interdependencies (Sosa et al., 2004, Magnusson and Lakemond, 2017) and it is established that complex product development relies on coordination through informal communication to reach a successful outcome (March and Simon, 1958, Thompson, 1967, Mintzberg, 1989). Informal structure can therein be considered enabling of plan-driven development (Indicated with ‘B’ in Figure 1). Moreover, with the formal change request processes associated with plan-driven development (Petersen and Wohlin, 2010) actors navigating the informal structures are incentivized to black out any deviations that can be excluded from formal reporting to maximize efficiency with respect to outcome.

Agile development and the informal organization

When agile software development was conceptualized by practitioners in the manifesto for agile software development (Beck et al., 2001) in 2001 (Dingsøyr et al., 2012) they were to a large extent motivated by "the crushing weight of corporate bureaucracy […] and the dehumanizing effects of detailed plan-driven development" (Boehm, 2002). They proposed ways of working that took the operative team, and not the bureaucracy or the plan, as the starting point. Accordingly, agile development and associated methods evolved to be customized for smaller settings with only one or a few small teams (Lindsjørn et al., 2018). The aim of these agile methods, agility, can be described as the ability to create valuable outcomes and effectively responding to change while keeping costs at a minimum (Dingsøyr et al., 2012).

According to Brunsson's (1989) distinction between formal and informal structures, agile development can quite clearly be positioned as rooted in the latter. The manifesto gives a set of guiding principles and emphasizes the value of informal communication, collaboration, working software and the ability to respond to change. Conversely, it deemphasizes the value of formal processes, documentation, contract negotiations and plans. Even though it should be noted that the manifesto explicitly states that there is value also in that which is deemphasized, the prioritized values clearly lie within the realm of Brunsson's (1989) informal structures in organization as cited above (Indicated with 'C' in Figure 1). Moreover, the manifesto quite clearly gives plans and formal processes a secondary 'if needed'-status (Indicated with 'D' in Figure 1).

Despite its informal origins, agile development seems to become increasingly formalized with its growing popularity. Nevertheless, Nerur and Balijepallyformalization". With ever more rapidly changing market conditions and increasingly complex products such questioning has proven justified and it is safe to say that agile development has become mainstream in software development (Stavru, 2014). With its popularity, it has cultivated several explicitly described team-based methods such as eXtreme Programming or 'XP', Scrum, Feature-driven development and Crystal methodologies (Dingsøyr et al., 2012). These methods are often described in detail and the most popular of these methods, Scrum (Stavru, 2014), has an official guide which contains a definition of Scrum that consists "of Scrum's roles, events, artifacts, and the rules that bind them together" (Sutherland and Schwaber, 2019) which indicates some degree of enabling formalization (Mintzberg, 1989).

The agile myth in plan-driven product development

While agile development emerged from small-scale informal constellations of developers (Lindsjørn et al., 2018), formal managers in large companies are now expected to understand and drive agile development (Rigby et al., 2016). The increasing popularity of agile development beyond its software origins makes it a myth in the institutional environment of product development organizations (Meyer and Rowan, 1977). It is becoming increasingly common within mechatronic and mechanical development (Rigby et al., 2016) and in product development organizations of a scale that allows for the development of airplanes (Rigby et al., 2018). Since the institutional environment primarily interacts with the formal structures in organization (Brunsson, 1989), this means that formal managers are set to adapt their organization to the agile myth which is far from a trivial matter (Boehm and Turner, 2005). Agile methods become design features in the formal design of plan-driven product development processes (Cooper, 2016) and managers are provided with advice for how to succeed when embracing agile (Rigby et al., 2016). However, formal leaders such as managers or project leaders are tightly embedded in the formal structures that define their roles (Mintzberg, 1989) and only loosely coupled with the informal structures where the actual work is carried out in the organization (Meyer and Rowan, 1977). There, technical deviations and issues are mostly managed by developers rather than the formally responsible managers (Munthe et al., 2014). Managers can encourage agile values in the organization. However, recalling that actors in the informal structure are incentivized to keep deviations under the formal radar, formal managers are unlikely to be fully aware of the extent to which agile values are already established in their organization. Ironically, they can clearly read and learn the formalized rules of agile methods. Moreover, with a presently plan-driven product development organization they can clearly identify how many of the present formal rules, roles and processes that are obsolete and accordingly need to be replaced by their agile counterparts.

Fertile grounds for agile in pan-driven product development

As previously stated, coordination through informal communication can be considered a necessity in order for large and complex product development to reach a successful outcome (Mintzberg, 1989, Sosa et al., 2004). Such coordination is referred to as mutual adjustment (Van de Ven et al., 1976) and is defined as communication under the condition of reciprocal interdependence among the communicating parties (Galbraith, 1968, Mintzberg, 1989). In accordance with its necessity in complex problem solving, mutual adjustment has been found particularly constructive for coordination among knowledge workers (Dingsøyr et al., 2017) and is also advised when tasks are difficult to analyze and when task interdependencies between work groups are high (Dietrich et al., 2013). The practices of the fundament of agile development and methods, the self-organizing agile team (Nerur and Balijepally, 2007, Hoda et al., 2012), can rather exhaustively be described in terms of mutual adjustment (Dingsøyr et al., 2017). Again, considering Brunsson's (1989) distinction between formal and informal structures, the latter has striking common ground with agile development also in the regard of the effective use of mutual adjustment. Consequently, while developers that are used to plan-driven approaches are likely to be unfamiliar with the formalized features of agile development, their embeddedness in the informal structures of the organization is likely to constitute a rich but carefully hidden asset of incorporated agile practices.

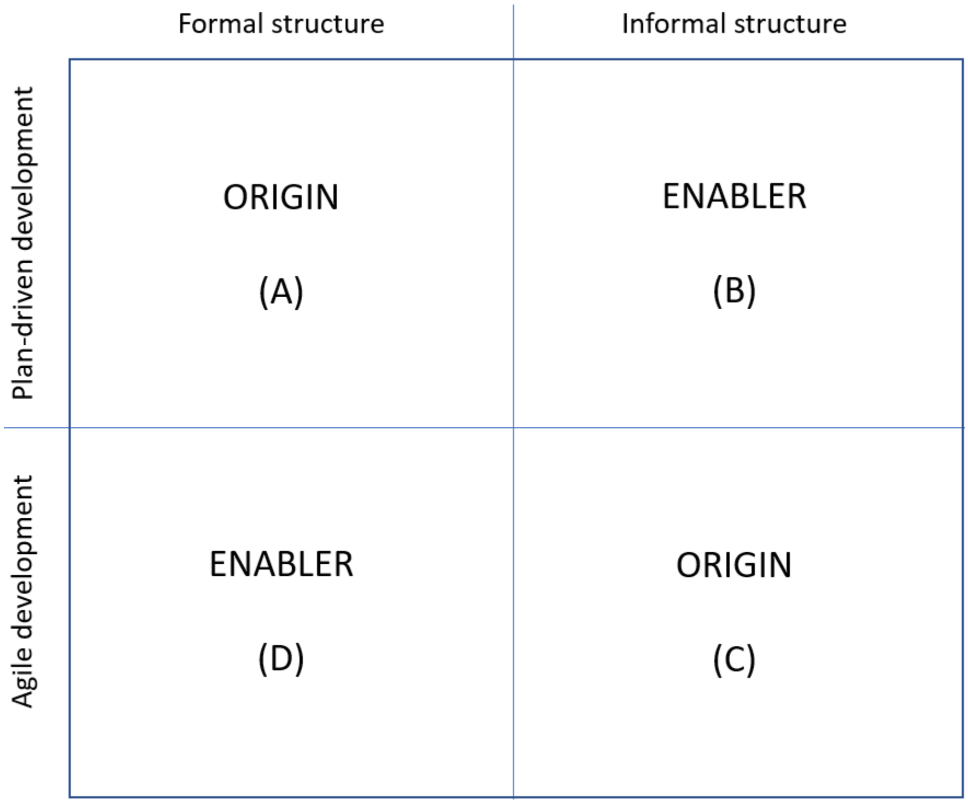

Figure 1. An illustration of the roles played by formal and informal structures in organization plays in relation to plan-driven and agile development respectively.

The paradox of institutionalizing agile

The enabling features of agile become the origins of its institutionalization in a presently plan-driven product development organization. In that way, the formal structure can become the driving force for agile to become a norm. Paradoxically, this means that the type of structure that agile product development was a reaction against now constrain the informal organization, the most fertile grounds for agile, with formal structures labeled ‘agile’. Nevertheless, the fertile grounds, coordinated action managed through informally structured mutual adjustment, are present also in plan-driven product development. How leadership is exercised in this process is arguably decisive for whether or not this asset is put to work in the institutionalization of the agile myth or not.

Formal leaders and leadership

Formal leaders in an organization play a significant instrumental role in the institutionalization of a myth. Washington et al. (2008) distinguish between organizational leadership on one hand and institutional leadership on the other. The former strive to set goals for the organization and identify challenges while the latter can be defined in according to the notion of institutional work (Kraatz, 2009) as described in a previous sub-section. However, by necessity, many of the actors in organizations that engage in institutional change are in fact organizational leaders assigned to the task of leadership as part of the formal organizational structure (Henceforth referred to simply as *formal leaders*), some of which are more prone to *leadership* than others. By representing the formal structure of an organization formal leaders will implicitly or explicitly contribute to institutionalizing myths, constraining the ongoing practices in the informal organization with new institutional conditions. Consequently, formal leaders are in a position where they can play a key role in mitigating the tensions between informal practice and formal structure in an organization through institutional work.

To understand how formal leaders can engage in institutional work there is a need to first conceptualize what leadership is. Theory on leadership in organizations is far from univocal. Most texts on leadership do not define it, and the remainder provide little consensus on its definition (Alvesson and Spicer, 2012). Moreover, scholarly work on leadership has been rather quiet about conflicting assumptions that underlie the various possible conceptions of it (Gronn and Ribbins, 1996).

Despite this unclarity of foundations, Crevani et al. (2010) identify and problematize a dominating view of leadership as tied to an individual, a leader, whereas in every day practice leadership activities seem to emerge from social interaction situated and embedded in specific contexts. They propose leadership as matter of performativity. As such, Alvesson and Spicer (2012) argue that leadership should be subjected to a reflexive approach that requires an ongoing dialogue about leadership in the context where it is exercised and more precisely about how it affects practice. They propose a critical performativity approach to leadership, using the word 'critical' to indicate a radical questioning of generally accepted assumptions of leadership as an authoritarian role. While clearly acknowledging the need for articulated leadership they stress that it is a situational matter and should be regarded as such.

A critical performativity approach to leadership seemingly has significant potential when engaging in institutional work as a formal leader, if the work is to re-make the connections between sets of practices including their cultural and moral foundations as proposed by Lawrence et al. (2009). The required form of leadership clearly cannot be enacted through direct supervision or standardization (Mintzberg, 1989) or through the setting of explicit goals (Washington et al., 2008) but the challenge for leaders becomes to supplement forms of control such as mutual adjustment with leadership if and when it might be needed. This represents a typical challenge that motivated the conceptualization of a critical performativity approach to leadership (Alvesson and Spicer, 2012). As part of further elaborations on critical performativity as an approach to leadership Spicer et al. (2016) suggest a concept referred to as 'leadership-on-demand' which nuances the leadership-follower relation and assumes the follower to be a co-constructor of leadership (Blom and Alvesson 2014).

Method

The empirical study is based on data from a longitudinal case study carried out at a product development organization in a Swedish automotive firm. The automotive firm will be addressed using the pseudonym "AutoTech Bil". The PD organization is involved in the development of software solutions related to passive and active safety functions. The product development (PD) organization will be addressed as PD unit 1. The study uses the tactic of exploring potentials which is suggested as suitable when approaching leadership through the lens of critical performativity (Spicer et al., 2009). Investigating potentials means to explore radical alternatives that are already existing in some form in the present, not in the sense of benchmarking but rather to pay attention to alternative practices embedded in the situation at hand (Spicer et al., 2016).

A single case design was chosen as the phenomenon is continuously evolving within a real-life context (Eisenhardt, 1989; Eisenhardt & Graebner, 2007; Hobday & Rush, 1999; Yin, 2009), and required an exploratory approach. In order to investigate potentials embedded in the present situation the study deals with understanding underlying reasons, motivations and opinions of personnel at a product development organization, an ethnographic data collection approach was deemed appropriate (Bryman and Bell, 2015).

Data collection through observations, interviews, document, archives etc., embodying an amalgamation of various types of qualitative data based upon 'participant as an observer' can be clustered under ethnographic data (Yin, 1994). Staying close to the case as a "participant observant" over a long period allowed for proximity to the nucleus of the case and the in-situ presence of the researcher is deemed crucial for identifying aspects that may not be evident through interviews, surveys or any other ex-post investigative techniques. Thus, this study builds upon data collected over a period of 10 months with one researcher being a participant actively listening to events as they unfold (Gerard Forsey, 2010b) and the other researcher being a former employee of the organization provided for deeper understanding of the case firm's way of working and the ongoing agile transformation.

The study also draws on institutional work, the study of which has overwhelmingly focused on retrospective narratives/anecdotes built upon interviews and archival data (Lawrence et al., 2013). Raviola and Norbäck (2013) illustrates the pitfalls of such retrospective studies. Lawrence et al. (2013) reiterated the role of emotions and experiences of individuals subjected to institutional work, thereby adding more value through the ethnographic study in the field of institutional work.

Data collection & analysis

Data was primarily collected by participant observation. As mentioned earlier, such qualitative data can be addressed as ethnographic data (Hannerz, 2003, Gerard Forsey, 2010a). For this study, observational data was deemed to be the most relevant as it empowers the researcher to identify nonverbal expressions, who interacts with whom, how actors communicate with each other, and catalogue events as they unfold (Kawulich, 2005). The researcher followed team discussion which allowed for collection observational data in the form of field notes. The field notes were then reviewed through data analysis software nVivo. Processing the field notes a narrative strategy was employed as it is the way that human beings best make sense of rich qualitative data (Bamberg, 2012). However, formulating narratives based on observations and experiences from the field is constructive both in the research process and in the presentation of research (Bamberg, 2012). This is used in the final synthesis of theoretical elaborations and empirical observations in this paper, through the presentation of personas and their interaction.

An empirical example

Industrial context

Historically, the automotive industry has for long focused on increasing volumes to decrease cost and is highly sensitive to pricing (Ili et al., 2010). Today, the industry is witnessing a shift in innovation practices due to discontinuity from both the technology and market perspective. The inherent complacency by the incumbent firms led to disregarding other forms of propulsions and alternate fuel sources (Mondragon et al., 2007). The motor vehicles are transforming at a rapid rate with increasing complexity that is beyond the competences and resources within the automotive firm's value network (Mondragon et al., 2007). Due to such drastic advancements in digital technology and alternate fuel sources, the automotive firms are at an ideal milieu to transition into an industry synonymous with open architectures as a way to leverage their hardware competences and couple them with ever-growing demand for better software and connected solutions for motor vehicles. New environmental regulations in developed nations and changes in customer preferences add further complexity to the innovation efforts of automotive firms. Also, the technology and product life cycles are becoming shorter due to rapid advancements in digital technology. In order to grapple with this seismic shift, automotive firms need to develop new strategies to stay competitive and innovate in an ever-shifting landscape. The magnitude of digital interfaces in modern cars are increasing exponentially (Pretschner et al., 2007). Studies in the past suggested that by 2010 a top segment vehicle would encompass one gigabyte of software, equivalent to that of a standard desktop

(Pretschner et al., 2007). This trend has continued to increase until now and automotive firms are pushing to build cars driven by software instead of humans. At the same breadth, in mature markets, customers expect more out of the car for the same price which translates into need for new functions such as park assist, lane keeping, adaptive cruise control. Although, the lowering cost of sensor and communication technology is a positive sign, car makers increasingly face cut-throat margins. In order to cater to demands of mature markets while keeping the price down, automotive firms increasingly depend on the knowledge base and efficiency of their R&D teams. The increasing cost of R&D combined with lowering margins in the automotive industry puts downward pressure on product development units to be more efficient, innovative, and flexible to market and technology dynamics. Today, the competition in the industry is shifting towards new turfs where digital innovations and alternate fuel sources are threatening the incumbent automotive firms' competences. New entrants in the automotive industry are predominantly technology firms with strong competence in machine learning and information technology. Such firms predominantly employ agile and adaptive ways of working is preferred (Rigby et al., 2018). In order to stay competitive in developing digital products and features, manufacturing firms are increasingly adopting agile way of work (Rigby et al., 2018). Thus, agile development philosophy is increasingly employed by manufacturing firms (Cooper and Sommer, 2018) to improve efficiency, effectiveness and to reduce R&D expenses.

The commonly used method on team level is scrum (Stavru, 2014) which is also employed by manufacturing firms (Cooper and Sommer, 2018). Bick et al. (2017) describe the method as a framework that employs new roles such as scrum master, product owner that is responsible for the product's business value and the self-organizing team. The self-organizing team is further described as cross-functional and consisting of seven (+/-2), supported by the scrum master who is the process facilitator and coach of the team. They also stress that the sprint lies at the heart of scrum, a time-boxed iterative work period of two to four weeks. In line with their description a sprint includes several defined meetings designed to facilitate coordination and work process-improvement and at the end of each sprint the team is expected to deliver working product increments.

A plan-driven organization imbibing the agile myth

This case study is based on "Autotech Bil", an automotive firm in Sweden with manufacturing hubs all across the world. More specifically, the study is based on one product development (PD) organization that develops Advanced Driver Assistance Systems (ADAS) and automation features. From here on, the PD organization will be addressed as PD unit 1. As an incumbent in the automotive industry, "AutoTech Bil" has a history of collaborating with other OEMs and suppliers in the industry. However, the nature of collaborations today is very different. Due to the extent of technologies involved in developing modern cars, "AutoTech

Bil” is increasingly engaging with actors outside the automotive industry. Until recently “AutoTech Bil” employed a plan-driven way of working. Due to the shift in the competitive landscape of the automotive industry (Lee et al., 2016), the nature of competences required to build cars has changed significantly. AutoTech Bil increasingly depends on Advanced Driver Assistance Systems (ADAS) and automation features to position itself as a market leader. Also, recent trends in automotive industry point towards electrification, fleet sharing and autonomation. Due to this, the traditional way of working seems to be less fit in a changing product landscape.

The plan-driven way of working which revolves around long range and detailed planning and dedicated checkpoints/gates seemed to be unfit for developing automation and other digital features. Many employees at PD unit 1 expressed frustration with the lack of flexibility with such well-defined planning approaches. In 2018, the ADAS and automation product development (PD) organization, started with what can be described as an agile transformation. It was decided that the entire PD unit 1 should shift from its plan-driven way of working to agile development. Even though the decision to ‘go agile’ applied to all the organizations at AutoTech Bil, they were allowed to some degree to choose the precise timing of the shift according to local plans and operations. The fieldwork for the present paper started shortly before the PD unit 1 had shifted into the agile ways of working. During the field observations, it was seen that this PD organization had interactions with software and technology firms.

Losing the informal agility in aid of formal agile development

The employees seem to understand and know how to discuss, plan and carry out work with their suppliers and other internal dependencies. Despite detailed requirements, the long-term planning following from a plan-driven way of working meant that employees could collaborate and develop informal networks undisturbed by formal structures during longer timeframes compared to the formally decided sprint structure that the agile development entails. It was observable that that the agile way of working would limit the ability to alter or deviate from set targets as the sprint plans, done for shorter time interval compared to previous waterfall development approach, provides little room to deviate from set goals. However, managers opined that agile methods facilitate greater flexibility and promote bottom-up planning of work. The managers felt that agile way of working empowers employees to plan their work on a team level. However, during the introduction of the agile way of working, many employees were anxious about the new terms, planning steps and team structures in the agile method. For example, the agile framework requires employees to assign load, story points, velocity etc. as per Scaled Agile Framework (Leffingwell, 2019). This was a completely new way of planning for the employees. Some of them expressed that it was difficult to estimate the amount of time they need for a particular task etc. Also, some team managers were frustrated before the implementation of agile. A manager expressed that it was hard to get proper information since the old structure had been removed while the new structure was not completely in place. Employees and managers alike felt that there was a lack of clarity and difficulty in understanding the new agile way of working during the early stages of the implementation process.

New constraints for informal coordination

During the transformation phase, some employees perceived the new agile way of working could be a mismatch due to AutoTech Bil's external network of suppliers and partners. Some employees expressed that working agile would create challenges in working with supplier. AutoTech Bil has been employing a plan-driven way of working for many years with long-term planning and regular gates/checkpoints. Developers who were accustomed to this way of working felt that the new agile set up could create new challenges, especially when it comes to collaborations with suppliers. As one of the employees said during a discussion session on introducing agile way of working *"..how do we work with supplier who does not work agile?" (Employee, AutoTech Bil)*. Another employee stated that sometimes, in the agile way or working, they have just one or two weeks to get a response from supplier. This highlights how the new way of working might constrain established ways of coordinating work with suppliers and also pointed at the same complications with other parts of the organization that had not yet introduced agile, or such that had a different interpretation of it stating that "some parts of [AutoTech Bil] are not agile yet and there will be conflicts".

As part of the agile transformation, cross-functional teams were set up with a scrum master per team. The entire product development unit (PD unit 1) was split into various functions with a product owner for each function. The teams were made of individuals coming from different areas of PD unit 1 and even from other product development organizations. Thus, we could see that the old networks and associations were broken down by the formation of new teams. Also, work in the newly formed agile unit had to be planned in sprints. Most of the time, tasks carried out by a team had dependencies towards other teams and sometimes even to suppliers and external partners. During the PI planning event, all teams shared their sprint plans and often designed their own plans based on the sprint plan of other teams. Thus, it was cumbersome for a team to alter the tasks in the upcoming sprint plans as it would create impediments for other teams to execute their plans.

Even though agile methods were designed to enable informal structures, the methods are seemingly perceived as new elements of the formal structures. Managers and formally appointed change agents seemingly intend to introduce the agile way of working to empower teams and so allow for bottom-up innovation. They see the agile planning techniques such as PI planning, sprint planning, sprint retrospective to be a good way to structure such work. However, developers perceived these new elements to a large extent as formal structures burdening them with new meetings and protocols.

The mute, the blind and leadership

In this section, we pick up the theoretical line of argument presented in the first sections of the paper and synthesize it with the developments observed at AutoTech Bil. Based on this we draw potentials from the perceived present state at AutoTech Bil for how formal managers can act to unlock the paradox of institutionalizing the agile myth. The section is concluded by a note on the theoretical contribution of the present paper.

The synthesis takes the form of two personas, *The Mute* who knows the origin of the agile myth in practice but lacks the appropriate vocabulary and associations to put it in words, and *The Blind* who is acquainted with the vocabulary of the myth but not intimately aware of what is going on in practice of daily operations. While The Blind represents the managers and formal leaders at AutoTech Bil, The Mute can be considered the collective of employed developers in the organization. The following synthesis should be considered a fictionalization to provide clarity to our theoretical line of argument exemplified based on the fieldwork at AutoTech Bil.

The Mute

In a plan-driven development setting The Mute is incentivized to manage deviations under the radar of formal structures as far as possible to avoid spending efforts in formal reporting and to maximize efficiency with respect to operative outcome. The Mute at AutoTech

Bil found ways of temporarily deviating from formally assigned targets in the plan-driven development to be able to meet long term goals. They were working around formally prescribed change request processes by simply working under the radar of formal structures. The Mute is embedded firmly in the informal structure of AutoTech Bil, the type of structure engaged in coordinating actions to provide for efficiency of operations and 'the reality' of 'actual work' (Brunsson, 1989, Meyer and Rowan, 1977). The Mute coordinates action within and across intra-organizational boundaries in whatever way efficiency of daily operations requires within the practical constraints of the formal structures. During the introduction of agile development at AutoTech Bil The Mute got anxious about all the new terms, planning steps and formal structures that were presented. Seemingly these novelties constitute new formal constraints that will have to be navigated, complicating daily work.

The Mute is stimulated by complex problems and prefers handling coordination through informal communication practices that constitute an invaluable resource for complex product development endeavors (Thompson, 1967, Mintzberg, 1989, March and Simon, 1958). The necessary informal social networks take time to develop and The Mute was consequently disturbed by the changed conditions induced by the formation of new team constellations at AutoTech Bil as agile development was introduced.

The Mute also handles the operative relations with suppliers and is therefore depending on established relations through which coordination can be managed informally within formal constraints. The misalignment, following the introduction of agile methods, between the internal formal structures and those of their suppliers forces The Mute to put efforts into developing new informal structures wherein mutual adjustment can be made possible.

The Blind

The Blind is formally assigned to leadership and is therein embedded in the formal structures of AutoTech Bil. As part of the formal structure The Blind is susceptible to changes in institutional norms and emerging myths (Brunsson, 1989), more so than The Mute. Moreover, The Mute uses the design of formal roles, job descriptions, rules and processes to align institutional norms with the internal operations. The Blind is not in day-to-day direct contact with the daily operations of the organization and therefore evaluates new methods and approaches based on what people say about them. In accordance, new institutional myths are adhered to because others seem to believe in them (Meyer and Rowan, 1977). The Blind has heard a lot about Agile development and believes that agile methods will enable more flexibility at AutoTech Bil and that it will empower and facilitate for The Mute to plan work and therein to be able to provide more transparency and predictability.

The Blind encourages agile values in the organization. However, recalling that The Mute is prone to using informal structures for both communication and operations The Blind has a hard time assessing the extent to which the agile values are infused in the organization. Nevertheless, the Blind believes that the new practices and procedures and planning methods introduced with agile development will infuse these values into the organization.

A potential for The Blind to lead The Mute

The Blind cannot see the details of how the employed developers manages day-to-day development work, simply because the Blind is fully occupied in the formal structure. Similarly, The Mute cannot describe the agility of present operations because she is not up to date with the vocabulary of the myth or how it is being institutionalized in the organization. Even though The Mute shares and enacts the values outlined in the manifesto for agile software development in the daily work the Blind has little chance of seeing it. The previous plan-driven way of working did not incentivize The Mute to share all the ins and outs of daily operations in formalized terms as this would mean a loss of agility within the plan-driven development process. The normative associations (Lawrence et al., 2009) connected to informal communication and coordination in the form of mutual adjustment therefore discourages The Mute from sharing details about these ways of working with The Blind.

Considering the institutionalization of the agile myth at AutoTech Bil, an important type of institutional work is addressing the assignment of new meanings to existing practices (Zilber, 2002). This means that the meanings of the practices carried out on a day-to-day basis by The Mute or The Blind need to be reviewed and reconsidered. In line with a critical performativity approach to leadership, The Blind and the Mute should engage in a dialogue about leadership and actively reflect about what it is and what role it should have to promote agile values. By asking about, and listening to how The Mute previously went about solving problems through mutual adjustment, informal networks and communication, The Blind would contradict the normative associations connected to such practices. Moreover, by connecting these inquiries to the formalized aspects of agile development The Mute would in part become unmuted contributing to the design of ways of working based own experience. Such a dialogue would constitute a bridge between the new formal structures entailed by the institutionalization of the agile myth (Indicated with 'D' in Figure 2), and the untapped agility of the informal structures evolved during the previously plan-driven approach (Indicated with 'B' in Figure 2). In this way existing informal structures would complement the predominantly formalized aspects of agile development that is implemented through formal structures in the institutionalization of the agile myth and provide a home-grown origin of agile development. This complementary role of existing informal structures is indicated with an arrow in Figure 2.

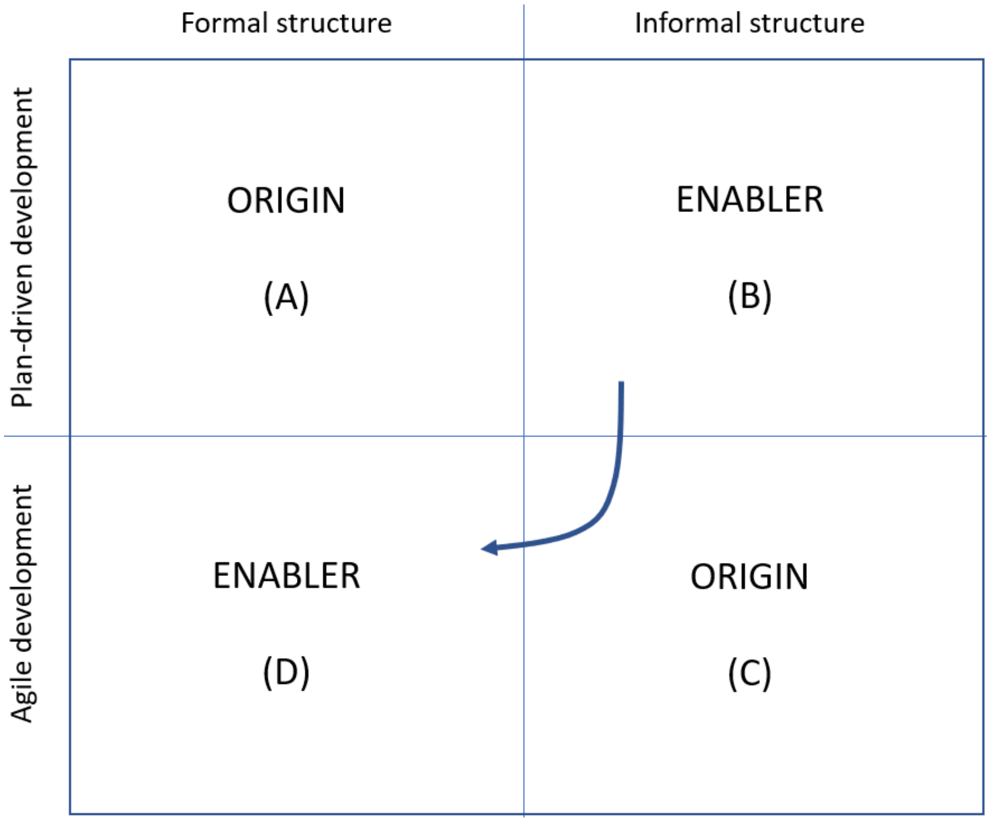

Figure 2. An illustration of the complementary role of informal structures (indicated by an arrow) that were developed during the previous plan-driven approach, in the institutionalization of the agile myth.

Theoretical contribution

The theoretical line of argument of this paper primarily contributes to the literature on agile development through clarifying underlying conflicts between agile and plan-driven development. This facilitates the understanding for potential conflicts that entail transitions from one to the other, an area where both case studies and further theory building are asked for (Dikert et al., 2016). Moreover, by proposing leadership-on-demand (Blom and Alvesson,

2014) as a way of moving from plan-driven to agile development, we connect a critical performativity approach to leadership to the literature on agile, which to our knowledge has not been done before but that contribute to the understanding of the role of the formal leader in agile development.

Using potentials drawn from observations of the present in ongoing ethnographic study we give a concrete example for how critical performativity can be used in the study of leadership therein contributing to a vivid scholarly debate (Butler et al., 2018, Alvesson and Spicer, 2012, Learmonth et al., 2016, Spicer et al., 2016, Gond and Nyberg, 2017, Gond et al., 2016). By using critical performativity to approach how formal leaders can exercise leadership specifically to address the institutionalization of a myth we also provide an empirical example of institutional work drawn from an ethnographic study. Something that is needed within the body of scholarly work on institutional work (Lawrence et al., 2013).

References

Alvesson, M. & Spicer, A. 2012. "Critical leadership studies: The case for critical performativity". Human relations, 65: 367-390.

Bamberg, M. 2012. "Narrative analysis". APA handbook of research methods in psychology, 2: 77-94.

Barley, S. R. & Tolbert, P. S. 1997. "Institutionalization and structuration: Studying the links between action and institution". Organization studies, 18: 93-117.

Beck, K., Beedle, M., Van Bennekum, A., Cockburn, A., Cunningham, W., Fowler, M., Grenning, J., Highsmith, J., Hunt, A. & Jeffries, R. 2001. *Manifesto for agile software development* Accessed: 2019.

Bick, S., Spohrer, K., Hoda, R., Scheerer, A. & Heinzl, A. 2017. "Coordination Challenges in Large-Scale Software Development: A Case Study of Planning Misalignment in Hybrid Settings". IEEE Transactions on Software Engineering.

Blom, M. & Alvesson, M. 2014. "Leadership On Demand: Followers as initiators and inhibitors of managerial leadership". Scandinavian Journal of Management, 30: 344-357.

Boehm, B. 2002. "Get ready for agile methods, with care". Computer, 35: 64-69.

Boehm, B. & Turner, R. 2005. "Management challenges to implementing agile processes in traditional development organizations". IEEE software, 22: 30-39.

Brunsson, N. 1989. *The organization of hypocrisy: Talk, decisions and actions in organizations*, John Wiley & Sons.

Bryman, A. & Bell, E. 2015. *Business research methods,* Oxford, Oxford Univ. Press.

Butler, N., Delaney, H. & Spoelstra, S. 2018. "Risky business: Reflections on critical performativity in practice". Organization, 25: 428-445.

Cooper, R. G. 2016. "Agile–Stage-Gate Hybrids: The Next Stage for Product Development Blending Agile and Stage-Gate methods can provide flexibility, speed, and improved communication in new-product development". Research-Technology Management, 59: 21-29.

Cooper, R. G. & Sommer, A. F. 2018. "Agile–Stage-Gate for Manufacturers: Changing the Way New Products Are Developed Integrating Agile project management methods into a Stage-Gate system offers both opportunities and challenges". Research-Technology Management, 61: 17-26.

Crevani, L., Lindgren, M. & Packendorff, J. 2010. "Leadership, not leaders: On the study of leadership as practices and interactions". Scandinavian Journal of Management, 26: 77-86.

Dietrich, P., Kujala, J. & Artto, K. 2013. "Inter-team coordination patterns and outcomes in multi-team projects". Project Management Journal, 44: 6-19.

Dikert, K., Paasivaara, M. & Lassenius, C. 2016. "Challenges and success factors for large-scale agile transformations: A systematic literature review". Journal of Systems and Software, 119: 87-108.

Dingsøyr, T., Bjørnson, F. O., Moe, N. B., Rolland, K. & Seim, E. A. Rethinking coordination in large-scale software development. Proceedings of the 11th International Workshop on Cooperative and Human Aspects of Software Engineering, 2018. ACM, 91-92.

Dingsøyr, T., Nerur, S., Balijepally, V. & Moe, N. B. 2012. A decade of agile methodologies: Towards explaining agile software development. Elsevier.

Dingsøyr, T., Rolland, K., Moe, N. B. & Seim, E. A. 2017. "Coordination in multi-team programmes: An investigation of the group mode in large-scale agile software development". Procedia Computer Science, 121**:** 123-128.

Galbraith, J. R. 1968. "Environmental and technological determinants of organization design: A case study".

Gerard Forsey, M. 2010a. "Ethnography as participant listening". 11**:** 558-572.

Gerard Forsey, M. J. E. 2010b. "Ethnography as participant listening". 11**:** 558-572.

Gond, J.-P. & Nyberg, D. 2017. "Materializing power to recover corporate social responsibility". Organization Studies, 38**:** 1127-1148.

Gond, J. P., Cabantous, L., Harding, N. & Learmonth, M. 2016. "What do we mean by performativity in organizational and management theory? The uses and abuses of performativity". International Journal of Management Reviews, 18**:** 440-463.

Gronn, P. & Ribbins, P. 1996. "Leaders in context: Postpositivist approaches to understanding educational leadership". Educational administration quarterly, 32**:** 452-473.

Hannerz, U. 2003. "Being there... and there... and there!:Reflections on Multi-Site Ethnography". 4**:** 201-216.

Hoda, R., Noble, J. & Marshall, S. 2012. "Developing a grounded theory to explain the practices of self-organizing Agile teams". Empirical Software Engineering, 17**:** 609-639.

Ili, S., Albers, A. & Miller, S. 2010. "Open innovation in the automotive industry". R&D Management, 40**:** 246-255.

Kawulich, B. B. Participant observation as a data collection method. Forum Qualitative Sozialforschung/Forum: Qualitative Social Research, 2005.

Kraatz, M. S. 2009. "Leadership as institutional work: A bridge to the other side". Institutional work: Actors and agency in institutional studies of organizations**:** 59-91.

Lawrence, T., Suddaby, R. & Leca, B. 2011. "Institutional work: Refocusing institutional studies of organization". Journal of management inquiry, 20**:** 52-58.

Lawrence, T. B., Leca, B. & Zilber, T. B. 2013. "Institutional work: Current research, new directions and overlooked issues". Organization Studies, 34**:** 1023-1033.

Lawrence, T. B., Suddaby, R. & Leca, B. 2009. *Institutional work: Actors and agency in institutional studies of organizations*, Cambridge university press.

Learmonth, M., Harding, N., Gond, J.-P. & Cabantous, L. 2016. "Moving critical performativity forward". Human Relations, 69**:** 251-256.

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.

Leffingwell, D. 2019. *Scaled Agile Framework* Accessed: 13th of January 2019.

Lindsjørn, Y., Bergersen, G. R., Dingsøyr, T. & Sjøberg, D. I. Teamwork Quality and Team Performance: Exploring Differences Between Small and Large Agile Projects. International Conference on Agile Software Development, 2018. Springer, 267-274.

Magnusson, T. & Lakemond, N. 2017. "Evolving schemes of interpretation: investigating the dual role of architectures in new product development". R&D Management, 47**:** 36-46.

March, J. G. & Simon, H. A. 1958. *Organizations,* USA, Wiley.

Meyer, J. W. & Rowan, B. 1977. "Institutionalized organizations: Formal structure as myth and ceremony". American journal of sociology, 83**:** 340-363.

Mintzberg, H. 1989. The structuring of organizations. *Readings in Strategic Management.* Springer.

Moe, N. B., Dingsøyr, T. & Dybå, T. 2009. "Overcoming barriers to self-management in software teams". IEEE software, 26.

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**:** 346-363.

Munthe, C. I., Uppvall, L., Engwall, M. & Dahlén, L. 2014. "Dealing with the devil of deviation: managing uncertainty during product development execution". R&D Management, 44**:** 203-216.

Nerur, S. & Balijepally, V. 2007. "Theoretical reflections on agile development methodologies". Communications of the ACM, 50**:** 79-83.

Petersen, K. & Wohlin, C. 2010. "The effect of moving from a plan-driven to an incremental software development approach with agile practices". Empirical Software Engineering, 15**:** 654-693.

Pretschner, A., Salzmann, C., Schatz, B. & Stauner, T. 4th international ICSE workshop on software engineering for automotive systems. Software Engineering-Companion, 2007. ICSE 2007 Companion. 29th International Conference on, 2007. IEEE, 146-146.

Raviola, E. & Norbäck, M. J. O. S. 2013. "Bringing technology and meaning into institutional work: Making news at an Italian business newspaper". 34**:** 1171-1194.

Rigby, D. K., Sutherland, J. & Noble, A. 2018. "Agile at Scale". Harvard Business Review**:** 88-96.

Rigby, D. K., Sutherland, J. & Takeuchi, H. 2016. "Embracing agile". Harvard Business Review, 94**:** 40-50.

Scott, R. W. & Davis, G. F. 2007. *Organizations and organizing,* New York, Routledge.

Seo, M.-G. & Creed, W. D. 2002. "Institutional contradictions, praxis, and institutional change: A dialectical perspective". Academy of management review, 27**:** 222-247.

Sosa, M. E., Eppinger, S. D. & Rowles, C. M. 2004. "The misalignment of product architecture and organizational structure in complex product development". Management science, 50**:** 1674-1689.

Sosa, M. E., Gargiulo, M. & Rowles, C. 2015. "Can informal communication networks disrupt coordination in new product development projects?". Organization Science, 26: 1059-1078.

Spicer, A., Alvesson, M. & Kärreman, D. 2009. "Critical performativity: The unfinished business of critical management studies". Human relations, 62: 537-560.

Spicer, A., Alvesson, M. & Kärreman, D. 2016. "Extending critical performativity". Human Relations, 69: 225-249.

Stavru, S. 2014. "A critical examination of recent industrial surveys on agile method usage". Journal of Systems and Software, 94: 87-97.

Sutherland, J. & Schwaber, K. 2019. *Scrum Guides* Available: www.scrumguides.org. Accessed: 13th of January 2019.

Thompson, J. D. 1967. Organizations in action: Social science bases of administration. New York: McGraw-Hill.

Van De Ven, A. H., Delbecq, A. L. & Koenig Jr, R. 1976. "Determinants of coordination modes within organizations". American sociological review: 322-338.

Washington, M., Boal, K. B. & Davis, J. N. 2008. "Institutional leadership: Past, present, and future". The Sage handbook of organizational institutionalism: 721-735.

Weick, K. E. 1976. "Educational organizations as loosely coupled systems". Administrative science quarterly: 1-19.

Zilber, T. B. 2002. "Institutionalization as an interplay between actions, meanings, and actors: The case of a rape crisis center in Israel". Academy of management journal, 45: 234-254.

Paper III

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The role of tactics in R&D: Insights from an autonomous car project

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In the pursuit for increasing organizational abilities to respond to external changes, agile is getting traction in the R&D divisions of large hardware-intensive firms. The upsurge in agile transformation programs renders challenges regarding conflicting logics and structures in relation to the legacy plan-driven approach. One of the key ideas of agile is the empowerment of teams. This means that the expectations on teams are changing in terms of what decisions they make and how they make them; and they are expected to take more responsibility for their decisions. In our longitudinal case study of an R&D project at Volvo Car Group that adopted agile, we see that expectations on teams not only include an increase of responsibility for decision making, they are also expected to make decisions of a different nature than before. We are motivated particularly by the observations that teams need to relate more to strategy and to other internal teams. By using observations from the project that recent shifted to agile development, we argue that tactics as a concept captures the essence of this shift in how teams make decisions.

Keywords: Agile transformation, tactics, R&D project, empowered teams, agility

1. INTRODUCTION

In today's dynamic environment, firms are seeking to develop flexibility in the projects. This is particularly important for new technology development projects that personify complexity and uncertainty. Digital technology is seen as a major disruptor in many mature industries. Consequently, being adaptive to changes becomes more important today than ever before. In light of this, firms are constantly exploring new processes and ways of working to facilitate this adaptiveness (D. K. Rigby, J. Sutherland, & H. Takeuchi, 2016). Agile as a development methodology, from being the modus operandi of software development projects, is becoming increasingly common with other types of development projects (Rigby et al., 2016). Partly as a result of the perceived inadequacies of current plan-driven approaches, and the convincing results of the deployment of agile in software development the past two decades, companies turn to agile for inspiration on how to conduct development which is not constrained to software.

Today, agile as a concept, which originated from team-based, small-scale software development, is translated into large-scale organization-wide context. This consequently fuels the debate on how to conceptualize agile in a large project (or organizational) context. One way to address this conceptual challenge, is to relate to three types of activities; strategic, tactical and operational. Interestingly, tactical activities and agile as a way of working both deals with adapting to emergent challenges and handling bottlenecks in projects (Ackoff, 1970; Hadar & Silberman, 2008; Rigby et al., 2016; Schultz, Slevin, & Pinto, 1987). Traditional plan-driven development approaches promote predictability and stability in a project whilst agile development deemphasizes strict plan-based control and instead promotes change management. Contrary to tolerating uncertainty or changes, plan-driven development often curtails the ability to pivot or adapt to emerging challenges.

Thus, the quest for nimbleness and adaptability in the project process pushes firms to employ tactics in day-to-day activities. Tactics, in general, is defined as the art or skill of employing available means to accomplish an end (Merriam-Webster, 2019). Tactical activities pertain to reacting to emergent challenges, handling uncertainty and anticipating bottlenecks during the implementation of a project. Both strategy and tactics are established in literature as essential for project success and academic works in the field of management addresses tactics as means to accomplish tasks or action-steps taken by firm to achieve its goal (Ackoff, 1970; R. Casadesus-Masanell et al., 2010; Moe, Aurum, Dybå, & Technology, 2012; Schultz et al., 1987). Slevin & Pinto (1987) describe the planning and implementation aspects of a project to consist of strategic and tactical activities. Often, the strategic activities involve top management involvement, and pertains to overall ambitions of the project and designing project plan. On the other hand, tactics often deals handling human, technical, and financial resources to achieve strategic ends. However, strategy is considered more important in the early phase of the project and tactical issues becoming more crucial during the implementation phase of the project (Slevin & Pinto, 1987). Tactics in a sense can be considered to play second fiddle to strategy, and supports in achieving the firm's strategic objectives (Hadar & Silberman, 2008; Harrington & Ottenbacher, 2009).

Despite the well-established importance of both tactics and strategy for project success (Slevin & Pinto, 1987), few academic works have addressed the challenges in being tactical in a plan-driven way of working. Thus, the objective in this paper is to better understand how agile methodology supports R&D projects in being tactical. To do so, we use data from a longitudinal case study on a technology development project that recently transitioned from a plan-driven to agile development methodology. Specifically, we seek to answer the following research question:

How does the transition from plan-driven to agile development influence tactical activities in new technology development projects?

2. FRAME OF REFERENCE

2.1. *LARGE SCALE AGILE DEVELOPMENT*

Transitioning from a plan-driven approach to a change-driven approach to R&D activities is getting increasing attention beyond the software community (Denning, 2016). The increasing pressure on companies in general to become more responsive to external and internal changes has coincided with the successful adoption of agile ways of working in software, and thus the ambitions to transform R&D organizations also outside of software businesses is getting more traction. The contrast between the iterative change driven agile approach and the established legacy approach based on stability and predictability becomes a challenge for companies interested on pursuing a transformation (Moe et al., 2012; Nerur, Mahapatra, & Mangalaraj, 2005). Agile promotes the empowerment of teams to reach agility through distributed decision making instead of centralized decision making (Hoda, Noble, & Marshall, 2012; Moe et al., 2012). Centralized decision making requires an organizational information processing capability that becomes overwhelming to maintain when the organizational complexity increases, and so the proponents of agile argue that decentralized decision enables teams to make faster decisions and thus become more agile (Highsmith & Cockburn, 2001). This means that a challenge that the organization in transformation needs to address is the shift of responsibility from management to the teams. This in turn implies two ensuing challenges; the acceptance of power from the team, and the surrender of power from the managers (Hempel, Zhang, & Han, 2012).

This means that the agile transformation imposes new expectations on the team. For example, they are expected to work in iterations, which results in more frequent decision making (Moe et al., 2012). They are expected to engage in a collaborative yet speedy decision processes (Cockburn & Highsmith, 2001). There is not just an increase in responsibility for their practices, but also new practices. Moe et al. (2012) observe an improvement of alignment between strategic, tactical and operational levels due to agile ways of working. This is explained by the increased collaboration between the representing agents of the three levels, but also that the self-managing teams hold more responsibility of the decision making on the tactical and operational levels. This indicates that teams under an agile paradigm are expected to act more tactically than under the plan-driven paradigm. Ultimately, what unifies agile practices and the notion of tactics is the ability to act under emergent circumstances. The activities of self-organizing agile teams emphasize the decision making in situ – acting on the unanticipated circumstances at hand, while informed by the overall strategy. As we will see, this is also what characterizes tactical maneuvering.

2.2. THE RELATION BETWEEN STRATEGY AND TACTICS

Activities in a project such as planning and decision making can be broadly classified to be strategic, tactical or operational (Harrington & Ottenbacher, 2009). However, the difference between strategy and tactics depends upon the unit of analysis or the location where the activity takes place in the firm. For example, from CEO's perspective, middle managers' activities may seem tactical but from the manager's perspective, these actions may seem strategic. Ackoff (1970) further strengthens this argument by emphasizing that activities' significance and their impact varies depending on the personnel involved and the unit of analysis. He differentiates between strategy and tactics based upon relative concepts such as 'long-term' and 'short-term', 'Broad' and 'narrow'; 'means' and 'ends'. All the concepts that are used to label an activity as strategic or tactical or operational is dependent on the unit of analysis and the context.

For this paper, we employ a relational view of tactics. Thus, we are interested in increases or decreases of tactical activities rather than establishing in absolute terms whether teams act tactically or not. This delta is identified by analyzing activities in terms of Ackoff's three dimensions: time, scope, impact (Ackoff, 1970; Schultz et al., 1987).

Over the past decades, firms have increasingly focused on better understanding their competitive environment in order to establish a sustainable advantage over their competitors (R. Casadesus-Masanell & J. E. Ricart, 2010) . In general, a management team is expected to support the business of both the project and the company. A project or program is a mechanism to initiate a change and thus needs to begin with a strategy (Williams & Samset, 2000). Thus, strategic project management is a popular discipline in the field of project management (Patanakul & Shenhar, 2012). In light of this, the field of strategy has gained traction amongst academicians and practitioners alike. The field of strategy guides firms in general objective setting, selecting a business model, development of new products or services (R. Casadesus-Masanell et al., 2012; Schultz et al., 1987). Although strategy provides the path for a firm to create value by utilizing its resources and competences, it does not address the challenges that may arise along the way. The strategic project management approach aims to achieve business results in line with the high-level enterprise strategy (Patanakul & Shenhar, 2012). Strategy is generally considered at the core of the managerial purpose (Bartlett & Ghoshal, 1994). However, in running daily activities, project managers seldom focus on business aspects as the impetus is on executing the tasks. This approach will deliver positive results in the project but may lead to abysmal business results for the company. Thus, strategic project management creates a synergy between project execution and higher business enterprise.

Managers aim to formulate and communicate convincing strategies to reach compelling goals. At the same time, members of the organization are occupied with their day-to-day activities, not seldom articulating other goals than their superiors (Floyd & Wooldridge, 1992). This detachment has paved way for important research on strategic consensus, where scholars are occupied with studying how strategies can affect the operational decision making in an organization – aligning individuals and resources towards a common goal (Boyer & McDermott, 1999; Kellermanns, Walter, Floyd, Lechner, & Shaw, 2011). The assumption behind strategic consensus is that for the coordination demanded by strategy implementation, action plans are needed but also need to be coupled with a shared understanding of the logic behind the action plan in relation to the strategy (Dess, 1987). This logic constitutes the warning mechanism for when action plans no longer are congruent with overall strategies. An action plan uncoupled from its logic will risk being deployed even if it becomes obsolete.

Further, strategy provides an overarching logic for the firm to participate in a business and how to compete in the market (R. Casadesus-Masanell et al., 2010). It supports the firm with executing its goals and business plans. On the other hand, tactics is used to facilitate the firm in achieving its strategy by laying out the way in which the firm should communicate, collaborate trouble shoot, compete etc. (Slevin & Pinto, 1987). While both strategy and tactics are important for the overall success of a business, it is established that tactics plays a big role in the execution phase of a new project. This is especially true when working with R&D projects where the technological and market uncertainty is high. Literature on projects highlight the importance of both strategy and tactics for project success (Schultz et al, 1987; Slevin & Pinto,1987). Schultz et al. (1987) emphasize that strategy is employed "in the early planning and more general objective-setting" whereas tactics consists of "action steps, or processes of task completion" taken in order to fulfil the strategy. With this in mind, we aim to contribute to how organizational ways of working in general, and the shift from plan-driven to agile in particular, influence the use of tactical decision making within the development teams.

2.3. NEED FOR FLEXIBILITY: PLAN-DRIVEN VS AGILE

The rapid advancements in digital technology has rendered firms to seek for flexibility and agility in their development projects. This search for flexibility had led to a whole host of new methods called agile development methodologies (Nerur et al., 2005). Despite the clear advantages – especially for systems development – of agile methodologies, firms deeply rooted in the traditional plan-driven methods will likely face significant challenges in adopting agile methodologies. Traditional development approaches are process-centric and aimed at eliminating variations (Nerur et al., 2005). Both agile and plan-driven way of working have pros and cons which invites the need to assess these methodologies together with its contextual environment. Traditional plan-driven development approach focus on providing stability and predictability in project (Li, Moe, Dyb, & #229, 2010) and are often ill-suited for projects that are laden with uncertainty. Agile development methodologies are set up to overcome such limitations with emphasis on continuous improvements, rapid feedback and tolerance to change (Nerur et al., 2005; Rigby et al., 2016a). Plan-driven way of working involves developing long-term plans. Such plans are usually developed by managers or decision makers with little input from employees. Due to this, it is difficult to alter plans or deviate from established goals. A way to promote flexibility in new product development lies in the way a project can deploy tactics (Ettlie & Subramaniam, 2004; Slevin & Pinto, 1987). However, little academic works in the past have focused on the role of agile methodologies in facilitating the use of tactics in daily operations and decision making.

3. Research design

This paper is based on a longitudinal case study of Volvo Car Group's autonomous car project. A case study approach was deemed suitable as we investigate a phenomenon that is embedded in a real-life context wherein the boundaries between the two are not evident (Yin, 1994) (Eisenhardt, 1989; Eisenhardt & Graebner, 2007; Hobday & Rush, 1999; Yin, 2009). A single case allows exploration of the dynamics of a phenomenon embedded in a complex relationship with its context. A longitudinal study is expected to facilitate a deeper understanding of the specific context, that is, how various agents (people) and units (teams) interact and the reasons for their interactions. Due to the emergent and unique nature of the phenomenon, the empirical data and theory were revisited concurrently to better understand the context. By moving back and forth between the empirical setting and the theory, our research design is in line with the systematic combining approach (Dubois & Gadde, 2002)

A case study is often misunderstood for particular data collection techniques such as ethnography or participant-observation. An ethnographic study involves long period of times in the field with detail observational data whereas participant-observation, although not to the level of ethnographic study, requires large amounts of field data. Ethnography involves visiting the subject's location (field) in order to observe and listen in a non-intrusive manner. On the other hand, a case study is a form of inquiry that does not depend on one specific data collection method (Yin, 1994).

3.1. Data collection and analysis:

Our research relies primarily on the data from the autonomous car technology development project. The first author spent around two years at the case firm as a 'participant observer'. The in-situ presence of the researcher is deemed crucial for identifying aspects that may not be evident or observable through interviews, surveys or any other ex-post investigative techniques The collected data consists of field notes (approximately 500 pages) that includes observations from numerous weekly meeting with important stakeholders and four PI planning events. We also use secondary data on current trends in the automotive industry to support the empirical observations. The first author also carried out 24 semi-structured interviews as part of the longitudinal study on 'innovation projects in large firms'. These interviews provided in-depth understanding of the project context and the shift of activities of interest to this paper.

Further, one of the authors being an employee at the case firm shared valuable insights pertaining to agile transformation and its impact on project planning and decision making. We draw on the advantages of employing an insider-outsider approach (Asselin, 2003; Dwyer & Buckle, 2009). The idea of the approach is to combine the benefits of having an insider who shares the experiences, language and identity with the individuals in the studied context, and an outsider who is distant from those commonalities and therefore more easily can relate to biases, prevailing paradigms and potential conflicts of interests. We rely on interplay between the two roles to gain insight into critical activities and phenomena in the studied context. The *insider* has spent 20 years at the firm, working in different capacities within the fields of Active Safety and Autonomous Drive. His experience in different organizational levels provides him with an ability to relate to specific organizational changes over time, including how the organization responds to changes, and how the current changes come into play with the organizational legacy. The main role of the insider is to bring forward these rich experiences, reflect on them in collaboration with the outsiders, and relate them to common patterns. The two *outsiders* have within the scope of a research project been working in close collaboration the company for more than two years, establishing a familiarity with the organization and individuals within it. One of the outsiders has spent a considerable amount of time on site during these two years, doing interviews, observing formal and informal communication events and meetings. The role of the outsiders is to join the insider in the analytical work and with an external perspective critically examine the empirical findings as a part of the analysis and drawing of conclusions. Thus, the third author played the role of an "insider" greatly ensured the validity of interpretations.

4. EMPIRICAL FINDINGS

4.1 EMPIRICAL CONTEXT : AUTOMOTIVE INDUSTRY

The automotive industry is witnessing an increase in innovation activity due to emerging technological and business needs in areas such as electrification, peer-to-peer car sharing services, and autonomous drive (AD) (Pelliccione et al., 2017). The advent of autonomous vehicles in particular has created a space for non-automotive firms to disrupt the automotive industry (Yun et al, 2016) and is considered to be the next major transformation in the industry.

Today, vehicles are increasingly becoming complex product systems encompassing advanced software along with hardware (Pelliccione et al., 2017). Due to rapid advances in communication, sensor systems and cloud infrastructure, etc., the innovation landscape in the industry is facing increasing complexity, beyond the competences and resources within the incumbents' value chain (Lee et al., 2016). However, incumbent automotive firms are persevering to develop competences within software and electronic technology in order to develop autonomous vehicles. These advancements have significantly increased the number of inter-firm collaborations in the industry. The AD technology is increasingly developed outside the OEMs' value chain and the incumbent firms need to interact with actors outside the industry to capture the required competences. Today, vehicles are becoming software-intensive complex systems. In light of this changing industrial landscape, automotive firms are increasingly engaging in software development. This has also led to a change in the way of working in projects. Many firms find the plan-driven development approach to be unsuitable for developing digital feature and are to an agile development approach (Pelliccione et al., 2017; Vaidya, 2014; Yusuf, Sarhadi, & Gunasekaran, 1999).

4.1.1. AUTONOMOUS CAR PROJECT AS A RELEASE TRAIN

Volvo Car Group (henceforth addressed as Volvo) is a Swedish automotive firm with 43,000 employees acknowledged as one of the market leaders in the area of safety (Liu et al, 2004) (VolvoCars, 2019). In recent years, Volvo has articulated its interest in the development of AD technology by investing immensely into its AD project (VolvoCars, 2019). The main purpose of the AD project is to develop the AD technology with necessary software and hardware system for a fully autonomous car. To do so, Volvo has put together several partnerships to collaborate with actors both within Sweden and internationally (VolvoCars, 2016, 2018).

Due to the current trends in the automotive industry, Volvo wanted to enhance cross-functionality, flexibility and closer interaction with its suppliers and customers. In order to do so, Volvo shifted from its plan-driven development method to agile in order to cope with the complexity and needs of present and future vehicles (Pelliccione et al., 2017). Although the entire firm decided to 'go agile', they were allowed to some degree to choose the precise timing of the shift according to local plans and operations. Volvo chose to use a framework for scaled agile transformation called SAFe ("Scaled Agile Framework").

4.2. AGILE TEAMS IN SAFE

After the agile transformation, the teams were given the mandate to plan their work. They were also permitted to distribute the work in the manner they deemed fit. During the initial stages of the agile transformation, employees had difficulty in adapting to the Scaled Agile Framework (SAFe). Scrum masters, who typically had experience with agile development often supported the teams to understand how agile planning works. A large amount of difficulty was pertaining to learning the SAFe method which consisted of new terms such as *epics, stories, solution train, agile release train, velocity, features etc.* The challenges with the adapting to the SAFe is illustrated by the quote below:

Right now it's much way of working[…]we have started to transform the teams on the lowest level […]so set the how the teams should work and set the agile process [...] the teams are becoming more and more stable[…]

(Senior Manager, AD project)

The middle management which includes the Scrum master, Product Owners, Release Train Engineer etc. played an important role in facilitating the teams in planning and decision making. Many employees perceived that the agile way of working empowered bottom up planning and allowed for flexibility in carrying out their tasks. However, this new found flexibility also meant that employees had more responsibility to plan their work and execute it in an orderly manner. Events such as daily stand-up, sprint demo, sprint review provided an opportunity for employees to evaluate their work and also improve for future.

"We need to have a good backlog to provide good input to the teams[…]what they should work with and so they are efficient and know what exactly they should do […]and then we have all the interaction with the vehicle program[…]that we should know what to deliver to the vehicle project and all the vehicle interfaces" *(Senior Manager, AD project)*

4.2.1. PROGRAM INCREMENT IN SAFE

Program Increment (PI) is the way in which work is structured in the SAFe methodology. Program Increment (PI) typically lasts 12 weeks and the Agile Release Train (ART) delivers value in each PI by working on developing software and systems (as shown in figure 1). The twelve weeks are further split into five sprints and one Innovation and Planning (IP) iteration that allows for demonstrating, sharing and learning from the sprints. The quote below illustrates the difference between current and previous plan-driven way of working.

"We should think about.. […]in the SAFe framework […]that we should breakdown features to […]it should be able to complete in 12 weeks and then you should break down them into stories and they you should finished in 2 week […]I think that is so much different from what we have done before"

(Senior Manager, AD project)

Each PI begins with a two days PI planning session wherein all the teams plan the activites for upcoming sprints and also highlight their dependencies with other agile teams and trains. Many employees perceived that the PI planning session was useful in identifying impediments and risks in the plans. They also discussed in depth on handling and mitigation the identified risks in the plans. Interestingly, during the PI planning sessions, the team identified major challenges in synchronizing with external suppliers. Also, during the first few PIs , employees perceived a slowdown in the planning process as most of them were new to the agile development approach. Many employees had to learn the different terminologies used in the SAFe method. Apart the learning the SAFe method, employees also found it difficult to change the way they approach the project activities. A senior manager opined that cost and time were primary drivers in the plan-driven way of working. This is illustrated by this quote from a senior employee:

"I am struggling coming[…]from being a traditional product leader[…]like we always say Time, Technique and cost at Volvo […]and we should consider that when presenting and delivering products"

(Senior Manager, AD project)

Since activities were planned for 12 weeks, the teams had to identify the most urgent and important tasks to be done. Due to the focus on developing sprint plans for the short term, the teams avoided dedication time for look at the long term challenges.

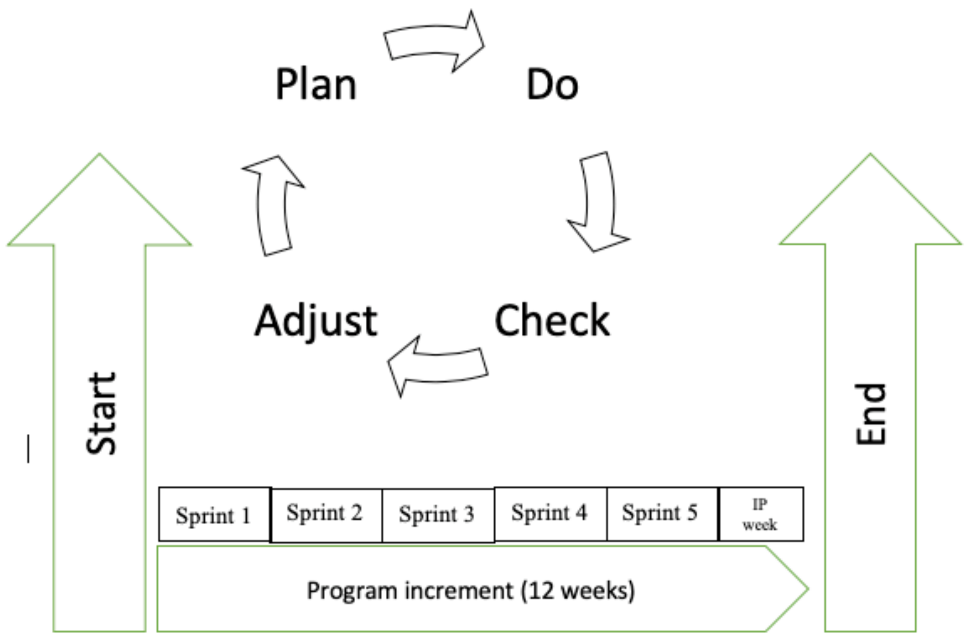

Figure 1. PI planning in SAFe (Agile, 2019)

4.3. OBSERVATIONS OF TACTICAL ACTIVITIES

In the following section, we present four observations from the longitudinal case study that illustrate how activities are carried out.

Observation A: "The legal framework uncertainty"

Context: Uncertainty in regulation

The AD technology currently lacks standards or legal framework. For example, the National Highway Traffic Safety Administration (NHTSA) in the U.S., has released AD guidelines to assist in defining safe autonomous driving vehicles. Apart from these AD guidelines, there are no regulations to define autonomous vehicles, except for autonomous driving testing requirements that have been released in many regions. In light of this regulatory uncertainty, it is perceived that Volvo's AD project may face unexpected challenges pertaining to regulations.

When developing new system solutions without defined legal framework, there is always a risk of major changes (to be done) in both hardware and software to meet future regulations when defined. One way of approaching these undefined boundary conditions is to ensure that requirements and system solution have built in the flexibility that allows for various mandatory requirements (that may affect both functionality and performance). To do this in practice, several potential solutions are needed – even if focus of main developments is one or two main tracks.

Observation B: "The documentation trade-off"

Context: Sprint planning session

Sprint planning is performed at the beginning of each spring event. The PI planning session develops overall plans for all the five sprints in the PI. During the sprint planning sessions, teams develop plans for the upcoming two weeks. In one of the sprint planning session, there was discussing on a task that involved writing extensive comments for software codes. This was seen as a solution to ensure everyone is able to understand what the code performs and thereby making it easier for new team members to continue with the work. The team had decided to use this particular sprint for preparing documents with detailed comments for all the codes. The Scrum Master (SM), on the other hand, realized that this task could be performed differently. As an experienced software developer, he was of the opinion that writing comments for codes does not help in the long run. Further, he added that codes are constantly improved where the comments are often not updated according to new changes in the code. He opined that people improve the codes constantly but seldom develop the comments. Instead, the SM suggested that the team should write a flow chart to explain the overall structure of the code and also ensure that the codes are not written with too many abbreviations or random names.

Observation C: "Handling unknowns"

Context: Develop a minimum viable product (MVP)

To develop a complex technological solution such as Autonomous Drive (AD) technology, it is important to build a minimum viable product (MVP) that can be used for trails and data-driven learning. A MVP facilitates testing and validation of the features being developed in the project. The MVP can then be used to expand scope based on future needs. Part of the difficulty in developing a MVP is the rapid advancements in sensor systems. Due to this, it is important that the AD project locks the sensor system as late as possible. However, the traditional plan-drive way of working severely constrained the ability to keep options open.

A response to this need to handle uncertainty with the system solution (while developing the MVP) led to the creation of an Operational Design Domain (ODD). An operational Design Domain (ODD) is the operational condition under which an automation system or feature is designed to function. In such a situation, the operational design domain (ODD) is a used to secure a MVP. The ODD involves defining the area in which the AD car will be used, environment conditions in the selected area and traffic safety scenarios involved.

The ODD then plays a crucial role in the selection of functions that relate to user experience, functional safety, energy efficiency, legal requirement etc. The functional requirements then determine the type sensor system, cleaning of sensors required for the car. A clearly defined ODD is used to derive the technical requirements for the system solution meeting functional safety and safety of intended function. This will define the boundary condition for a system solution and the autonomous driving functionality, with regards to allowed vehicle speeds, type of roads, environmental conditions etc. To facilitate future development, flexibility, and user experience, a cloud-based Operational Domain can be dynamically controlled. This can increase future availability of the autonomous driving vehicle and reduce events with late detected conditions outside ODD, i.e. inconvenient minimum risk maneuvers.

Observation D: "Suppliers and components"

Context: Selecting suppliers, technologies, etc.

Technologies such as Lidar, sensors, cameras, graphic processing units (GPUs), radars etc. are continuously improving in performance and cost. This means that the AD project cannot decide or begin production with the components or system currently available. However, development work involves testing of autonomous system in simulated and real traffic. For the use of a test vehicle, however, the project needs to use technologies in the market and utilize current technologies that can facilitate the understanding of potentials with future upgrades with sensors, lidar and other technologies.

Along with the performance dimension of technologies/components, firms that supply them also play a vital role in the project. Competition between, business interests, ability to deliver, etc. also make it difficult for the project to commit or establish contracts prematurely. The improvements in technology may also alter the novelty and capabilities of individual supplier.

Also, other services such as cloud infrastructure, maps, etc. play an important part in the AD technology development. These suppliers are often locked to a particular market or geography. For example: In this area of maps, the project has to consider that some suppliers work in one region and find it difficult to expand and are often locked to their markets. Thus, the project needs to pay attention to both quality of the product and also if the suppliers can be meet requirements such as collaborate with other suppliers etc. This is illustrated by the quote below:

"*We need to be modular because someone like Firm A would not want to be involved with Firm B. So, we need to think about this as well"*

5. ANALYSIS

In order to identify the use of tactics in the agile project, we use literature on agile development, and project management. The importance of strategy and tactics for project success is well established in literature. However, both strategy and tactics is used interchangeably by practitioners with little attention paid to differences between the two terms. In this paper, we identify tactics based on the following attributes: Time (long term or short term), scope (wide or narrow) and impact (local or entire project) (Ackoff, 1970; Schultz et al., 1987). We observe that expectations on teams do not only include an increase of responsibility for decision making, they are also expected to make decisions of a different nature than before. In order to distinguish the use of tactics, we use our analytical framework from Chapter 2, for each of the observations respectively:

Observation A: "The legal framework uncertainty"

Unclear legal framework necessitates Volvo's AD project to work on multiple tracks. Since traffic safety is main focus for established legal frameworks, the AD project uses it as a guiding principle to secure the system solution. This way, it can ensured that the AD cars always meet functional safety and thereby secure safety of intended function(s). In order to reduce unexpected bottlenecks due to legislations/regulations, the technology developments is done with multiple tracks or focus worst case scenarios. By doing so, the teams in the project can find alternative paths to proceed with their development work if needed. To better handle with such uncertainties, the project aims to work on the assumption that functional safety and safety of intended function will be the foundation for any legal framework. Thus, a solid foundation for functional safety helps the project to stay ahead of regulation on safety and other such requirements.

We observe that the AD project reduces uncertainty pertaining to regulations by developing dual tracks for system solutions. The enables the AD project to keep options open. In line with literature on strategy and tactics (Ackoff, 1970; Ettlie & Subramaniam, 2004; Schultz et al., 1987), we find that working with multiple scenarios does not impact the long term project objectives. The scenarios are used as a means to navigate through a cumbersome regulatory landscape rather than deviate from set objective. Also, the duration of such multiple scenarios are a short term operation and only needed until there is uncertainty in regulations.

Using our framework to distinguish strategy from tactics, we find that the manner in which the project handled unclear legislation was a short-term solution and narrow in scope. Thus, we identify the action to be tactical in nature (Ackoff, 1970; Schultz et al., 1987). Further, plan-driven development method does not permit for flexibility or work with multiple tracks due to the focus on reducing cost and uncertainty (Guillermo, 1999; Rigby et al., 2016a; Yusuf et al., 1999). On the contrary, agile development provides the ability to adapt to changes. This is seen as a key strength compared to traditional plan-driven way of working (Nerur et al., 2005).

Observation B: "The documentation trade-off"

This exhibit illustrates that despite the middle management's set plan, the team decided to find an alternative solution. In this example, we see that the management gave the mandate to the teams to deviate from original plans. Thus, the team decided to iterate the plan and decided to do alter the plan as they felt that the previous plan was time consuming and less effective.

In essence, the team engaged in tactical planning to find the best possible way to finish the task. Although, it can be argued that the act of coming up with a new plan or decision can be strategic in nature, we observe that from a project level, changing a plan at a team level does not influence or impact the overall goals of the project. Also, the task was narrow in scope as it dealt with a particular task of writing comments for codes. Thus, in line with literature on tactics, the actions taken at the team level illustrate the ability to work tactically in an agile organization (Ackoff, 1970; Schultz et al., 1987). The ability of the operational level employees to deviate from established plans would be cumbersome to execute in a plan-driven way of working (Nerur et al., 2005).

Observation C: "Handling unknowns"

The operation design domain (ODD) was a key to building the MVP. The ODD can be developed with options open for future progress and needs. This way, the AD technology can be continuously improved and be in sync with developments in other technologies and components. In the future, an Operational Domain can also be increased when new functionality have been developed and verified (within defined ODD).

Typical examples of ODD can be driving in dark conditions, heavy rain and new road types. With a system solution including an Operational Domain tool, a MVP can be defined. But this does not restrict future functional or performance growths (within limitations). This is a useful tool to secure future development flexibility suitable for agile development process. In a typical development process, the launched product will be defined and optimized at launch. Further improvements can potentially be made, but at higher risk for unknown limiting factors in the system solution. Interestingly, the ODD was a result of the project's search to handle uncertainty in sensor technology. Thus, in line with literature of tactics, the project found a way to keep options open but at the same time allow for developing the MVP. The ODD, we find to be, a short-term solution to handle uncertainty in the area of sensor systems (Ackoff, 1970; Schultz et al., 1987). Also, the agile way of working facilitated the project to secure the MVP but also have the ability to make changes in the future. Based on literature on tactics and strategy, we identify that this decision could be argued to be tactical (Ackoff, 1970; Schultz et al., 1987; Slevin & Pinto, 1987). Further, in a plan-driven development method, it would be difficult for the project to implement this (Nerur et al., 2005).

Observation D: "Suppliers and components"

The rapid advancements in various technologies necessitates the AD project to choose components and suppliers as late as possible. This is because, deciding to freeze the technology that is available today may compromise the ability to improve the functionality at a later period. In line with literature (R. Casadesus-Masanell & J. E. Ricart, 2010; Hadar & Silberman, 2008; Nerur et al., 2005; Schultz et al., 1987),

we find that the opting to work with available technology and services with a development vehicle is short term solution to handle uncertainty. It is also narrow in scope as the intended function of the AD technology is not alerted or undermined. Further, the decision to keep options open for upgrading technology or select suppliers is not a deviation but a tactical move right from the outset, thus being low on the impact factor. Consequently, we observe that the ability to work with development vehicle while maintaining flexibility to add upgrade technologies, choose suppliers is tactical in nature and the agile way of working allows for such changes in the system. Thus, we find that the agile development method improves the ability to being tactical in the development process.

6. CONCLUDING DISCUSSION

The project we have studied faces high levels of uncertainty and together with the complexity of the technology, it necessitated Volvo to make frequent and rapid changes to its plans and development work. Literature on agile development methods abundantly illustrate its advantages in terms of being conducive for fast changes through iterations, cross-functionality, improved collaboration etc. From observations and insider experiences, we find that the agile transformation that the development project went through shifted the activities within teams towards activities of a more tactical nature than before.

The shift in power from middle management level to the team level not only meant more responsibility allocated to the team, but also a shift in team level practice – from operational to tactical activities. Also, we find that the shift to agile significantly improved the projects ability to handle uncertainty and emergent needs. From this, we suggest that the agile methodology supports and promotes team level decision making that is limited in time, scope and impact but still aligned with an overall strategy. We refer to this as being tactical. We also suggest that the distinction between strategy, tactics and operations is useful in conceptualizing the difference in activities and practices that the teams are expected to adhere to as a part of an agile transformation.

This conceptualization is useful as it provides a framework for how to describe the shift that the team is going through, including what expectations they need to meet as a result of an agile transformation. Teams will need to develop new skills related to tactical thinking. It is not enough to assume responsibility for their practices from before the transformation, but they will now need to reflect on their practices and how they contribute to the overall strategy, as well as be able to design and alter practices as they go. From the managerial perspective, the role of managing the team shifts from providing the team with tactics according to the plan and respond to the team's signals of inadequate tactics, to facilitating the team's tactical activities and providing the overview that they need to relate their tactical maneuvering to the overall strategies of the organization.

After the agile transformation, it was noticeable that there was pronounced increase in the utilization of tactics. The project faces high levels of uncertainty and the complexity of the technology necessitates Volvo to make fast changes to its plans and development work. Literature on agile development methods abundantly illustrate the advantages of it being conducive for fast changes, cross-functionality, better customer collaboration etc. (Highsmith & Cockburn, 2001; Nerur et al., 2005; Rigby et al., 2016a). In line with this, we find that implementation of the agile development enhanced the project to be more tactical compared to traditional plan driven way of working (as shown in figure 2). Through four observations and studying the agile way of working, we illustrate how the agile way of working greatly improves the ability to be tactical during the development phase of a project riddled with uncertainty and risk.

Thus, this paper illustrates the role of agile methods in promoting tactical activities in R&D projects by investigating a project that recently shifted from plan-driven to agile way of working. By using observational data, interviews and insider stories from the case study, we shed light on the importance of tactics in such complex technology development projects.

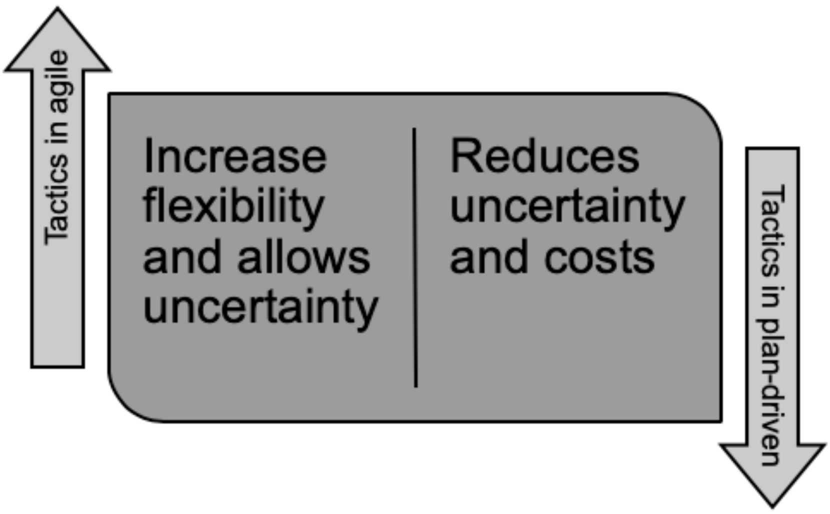

Figure 2. Ability to handle uncertainty in agile and plan-driven way of working

REFERENCES:

Ackoff, R. J. L. R. P. (1970). A concept of corporate planning. *3*(1), 2-8.

Agile, S. (2019). Scaled Agile (2019). Scaled Agile Framework – SAFe for Lean Enterprises. Retrieved from https://www.scaledagileframework.com/

Asselin, M. E. (2003). Insider research: Issues to consider when doing qualitative research in your own setting. *Journal for Nurses in Professional Development, 19*(2), 99-103.

Bartlett, C. A., & Ghoshal, S. (1994). Changing the role of top management: beyond strategy to purpose. *Harvard Business Review, 72*(6), 79-88.

Boyer, K. K., & McDermott, C. (1999). Strategic consensus in operations strategy. *Journal of Operations Management, 17*(3), 289-305. doi:https://doi.org/10.1016/S0272-6963(98)00042-4

Casadesus-Masanell, R., & Ricart, J. E. (2010). From Strategy to Business Models and onto Tactics. *Long Range Planning, 43*(2), 195-215. doi:https://doi.org/10.1016/j.lrp.2010.01.004

Casadesus-Masanell, R., & Ricart, J. E. J. L. r. p. (2010). From strategy to business models and onto tactics. *43*(2-3), 195-215.

Denning, S. (2016). How to make the whole organization "Agile". *44*(4), 10-17. doi:doi:10.1108/SL-06-2016-0043

Dess, G. G. (1987). Consensus on strategy formulation and organizational performance: Competitors in a fragmented industry. *Strategic Management Journal, 8*(3), 259-277.

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

Dwyer, S. C., & Buckle, J. L. (2009). The space between: On being an insider-outsider in qualitative research. *International journal of qualitative methods, 8*(1), 54-63.

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

Eisenhardt, K. M., & Graebner, M. E. (2007). Theory Building from Cases: Opportunities and Challenges. *The Academy of Management Journal, 50*(1), 25-32. doi:10.2307/20159839

Ettlie, J. E., & Subramaniam, M. (2004). Changing Strategies and Tactics for New Product Development. *21*(2), 95-109. doi:doi:10.1111/j.0737-6782.2004.00060.x

Floyd, S. W., & Wooldridge, B. (1992). Managing strategic consensus: the foundation of effective implementation. *Academy of Management Perspectives, 6*(4), 27-39.

Guillermo, P. B. (1999). Knowledge management in agile innovative organisations. *Journal of Knowledge Management, 3*(1), 6-17. doi:doi:10.1108/13673279910259358

Hadar, E., & Silberman, G. M. (2008). *Agile architecture methodology: long term strategy interleaved with short term tactics.* Paper presented at the Companion to the 23rd ACM SIGPLAN conference on Object-oriented programming systems languages and applications.

Harrington, R. J., & Ottenbacher, M. C. (2009). Decision-Making Tactics and Contextual Features: Strategic, Tactical and Operational Implications. *International Journal of Hospitality & Tourism Administration, 10*(1), 25-43. doi:10.1080/15256480802557259

Hempel, P. S., Zhang, Z.-X., & Han, Y. (2012). Team Empowerment and the Organizational Context:Decentralization and the Contrasting Effects of Formalization. *38*(2), 475-501. doi:10.1177/0149206309342891

Highsmith, J., & Cockburn, A. J. C. (2001). Agile software development: The business of innovation. *34*(9), 120-127.

Hobday, M., & Rush, H. (1999). Technology management in complex product systems (CoPS) - ten questions answered. *International Journal of Technology Management, 17*(6), 618-638. doi:10.1504/IJTM.1999.002739

Hoda, R., Noble, J., & Marshall, S. J. E. S. E. (2012). Developing a grounded theory to explain the practices of self-organizing Agile teams. *17*(6), 609-639. doi:10.1007/s10664-011-9161-0

Kellermanns, F. W., Walter, J., Floyd, S. W., Lechner, C., & Shaw, J. C. (2011). To agree or not to agree? A meta-analytical review of strategic consensus and organizational performance. *Journal of Business Research, 64*(2), 126-133. doi:https://doi.org/10.1016/j.jbusres.2010.02.004

Li, J., Moe, N. B., Dyb, T., & #229. (2010). *Transition from a plan-driven process to Scrum: a longitudinal case study on software quality*. Paper presented at the Proceedings of the 2010 ACM-IEEE International Symposium on Empirical Software Engineering and Measurement, Bolzano-Bozen, Italy.

Moe, N. B., Aurum, A., Dybå, T. J. I., & Technology, S. (2012). Challenges of shared decision-making: A multiple case study of agile software development. *54*(8), 853-865.

Nerur, S., Mahapatra, R., & Mangalaraj, G. J. C. o. t. A. (2005). Challenges of migrating to agile methodologies. *48*(5), 72-78.

Patanakul, P., & Shenhar, A. J. (2012). What project strategy really is: The fundamental building block in strategic project management. *43*(1), 4-20. doi:10.1002/pmj.20282

Pelliccione, P., Knauss, E., Heldal, R., Magnus Ågren, S., Mallozzi, P., Alminger, A., & Borgentun, D. (2017). Automotive Architecture Framework: The experience of Volvo Cars. *Journal of Systems Architecture, 77*, 83-100. doi:https://doi.org/10.1016/j.sysarc.2017.02.005

Rigby, D. K., Sutherland, J., & Takeuchi, H. (2016a). Embracing agile. *Harvard Business Review, 94*(5), 40-50.

Schultz, R. L., Slevin, D. P., & Pinto, J. K. (1987). Strategy and Tactics in a Process Model of Project Implementation. *17*(3), 34-46. doi:10.1287/inte.17.3.34

Slevin, D. P., & Pinto, J. K. J. S. m. r. (1987). Balancing strategy and tactics in project implementation. *29*(1), 33-41.

Vaidya, A. (2014). Does dad know best, is it better to do less or just be safe? adapting scaling agile practices into the enterprise. *PNSQC. ORG*, 1-18.

VolvoCars. (2016). Volvo Cars and Uber join forces to develop autonomous driving cars. Retrieved from https://www.media.volvocars.com/global/en-gb/media/pressreleases/194795/volvo-cars-and-uber-join-forces-to-develop-autonomous-driving-cars

VolvoCars. (2018). Volvo Cars and Baidu join forces to develop and manufacture autonomous driving cars.

VolvoCars. (2019). The Future of Driving | Volvo Cars. Retrieved from https://www.volvocars.com/intl/buy/the-future-of-driving

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

Yusuf, Y. Y., Sarhadi, M., & Gunasekaran, A. (1999). Agile manufacturing:: The drivers, concepts and attributes. *International Journal of production economics, 62*(1-2), 33-43.

Paper IV

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From a joint venture to an innovation ecosystem: Lessons from a longitudinal study of an autonomous drive technology development project

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INTRODUCTION

As far back as the 1990s, it was recognized that the complexity related to new technologies and the level of global competition were increasing R&D costs, making it difficult for single firms to develop new technology (Adner *et al.*, 2010; Gawer *et al.*, 2014; Kamien *et al.*, 1992). Customers are demanding more complex solutions that require specialized capabilities (Williamson *et al.*, 2012) and innovation activities are increasingly distributed and involving firms in different industries along with customers and even competitors in a collective process. (Brusoni *et al*., 2013; Iansiti *et al.*, 2004).

Since it is difficult for a single firm to encompass all the required capabilities and competencies, inter-firm collaborations are becoming more prominent. For example, Joint Ventures (JVs) enable engagement in risky technology development projects where standard business objectives, such as market attractiveness, profitability, etc., are unclear (Anderson, 1990). The JV enables each participating firm to minimize its risk and to spend less than would be required if it acted alone (Kamien *et al*., 1992). Collaboration also eliminates duplication of research efforts and reduces competition which could slow the rate of technological advancement. However, new technologies developed via joint ventures do not automatically result in successful innovation. Moreover, innovations that are radical in nature, seldom succeed in isolation (Adner, 2006), as they often lack the complementary assets needed to create value to the customer. Tripsas (1997) argues that possession of relevant complementary assets allows incumbent firms to survive competence destroying technological change. However, establishing these complementarities requires inter-firm collaboration beyond a JV and may then take the form of an ecosystem (Williamson *et al.*, 2012).

The term 'ecosystem' is used to describe value creation activities involving organizations connected to a keystone firm or a platform in a non-linear system, and includes both participants from the production and use sides (Adner *et al.*, 2010; Iansiti *et al.*, 2004;

Moore, 1993; Oh *et al.*, 2016). The notion of ecosystem is attracting much research attention (Oh *et al*., 2016) and the term is being applied in multiple contexts (Jacobides et al., 2018). Further, Jacobides *et al.* (2018) suggest that modularity and complementarity are important ecosystem underpinnings. However, not all firms are able to establish modular architectures.

Much remains to be learned about how new ecosystems emerge (Jacobides *et al*., 2018) and how they are influenced by different actors. Research on the emergent phase of an ecosystem is scarce since investigating somewhat unknown entities is difficult (Dattée et al., 2018; Gawer et al., 2014; Jacobides et al., 2018). A long-term perspective is required to trace the origins of an ecosystem since its development can take many years. To try to understand how an ecosystem emerges, it is useful to study new technology collaborations since technological change is at the base of radical innovation. In their value creation phase, ecosystems are termed ‘innovation ecosystems’ (Adner, 2006; Gomes et al., 2018; Jacobides et al., 2018).

The purpose of this paper is create a better understanding of the emergence of new innovation ecosystems[1] and the role played by the keystone firm. This paper builds on a longitudinal study (30 months) of an Autonomous Drive (AD) technology development program at Volvo Car Group (henceforth addressed as Volvo), focusing on the collaborative set-up around AD technology development.

We show how the resource and competence needs linked to the AD technology development, pushed Volvo to form a JV with Veoneer (previously a part of Autoliv). The JV implicitly facilitated the development of a modular system, making it easier to establish collaborations related to the technology. Further, we show how Volvo was established as the keystone firm and implicitly nurtured the formation of an innovation ecosystem.

Innovation ecosystem focuses on the value creation proposition and involves the actors collaborating on the innovation activities. A business ecosystem consists of the firms involved in value capture (Scaringella *et al.,* 2018; Jacobides *et al.,* 2018).

We contribute to the academic discourse by proposing the notion of “symbiotic” JV and add to knowledge on innovation ecosystem by illustrating how modularity, acknowledged to be crucial for a new ecosystem to emerge (Jacobides *et al.*, 2018), can be achieved when developing a new technology.

FRAME OF REFERENCE

Inter-firm collaborations

Economic theories and literature on industry dynamics explain the role of technology in shaping innovation (Christensen et al., 1995; Klepper, 1997). The emergence of a new technology attracts new entrants, which intensifies the competition amongst firms to establish a dominant design for future products (Anderson et al., 1990; Henderson et al., 1990; Utterback et al., 1993). The innovation literature frequently attributes the failure of incumbent firms to discontinuous technological change (Klepper, 1997; Utterback et al., 1993). However, not all incumbent firms fail; some both retain and strengthen their competitive position over time. It has been shown that successful incumbent firms are those with the capacity to absorb new technologies and enhance their capabilities (Bergek et al., 2008). Thus, competitive industry settings combined with uncertain profit potential and new technology complexity, motivate firms to enter into alliances and partnerships (Anderson et al., 1990; Harrigan, 1988).

In empirical studies of new technology development, collaborations between firms play a significant role (Ahuja, 2000; Hagedoorn, 2002; Hagedoorn, 1993; Lambe *et al.*, 1997). However, literature on inter-firm collaborations does not adequately describe the environmental conditions influencing the choice of a particular form of collaboration (Gawer et al., 2014). To remain competitive, firms are increasingly opening up their innovation processes and collaborating with suppliers, customers and competitors (Chesbrough, 2010) in order to access their knowledge and capabilities (Johansson et al., 2011).

The literature proposes two main reasons for alliances or cooperation among firms (Ahuja, 2000). One explanation is related to the firm's strategic resource needs; the other suggests that interfirm linkages build on experience of previous partnerships and implies that current alliances are based on the firm's position in the network structure (Ahuja, 2000). The resource-based view suggests that firm behavior is shaped by its quest for competences and resources that can provide competitive advantage (Ahuja, 2000; Wernerfelt, 1984). Resources tend to be firm-specific and provide value creation opportunities for the firms in possession of them. Further, they cannot be developed instantaneously but must be accumulated over time. Thus, engagement in alliances and partnerships stems from the firm's need to secure resources and competences, not easily purchased on the market or developed internally.

The development of a knowledge base and technological competence is difficult, time consuming and expensive, and technological and market uncertainties exacerbate the problems related to technology development (Ahuja, 2000). Development of technological capabilities can involve frustrations and is a costly and uncertain endeavor. Firms that try to develop technology on their own can find it difficult and expensive to catch up with first movers. New and superior technology is crucial for product innovation (Brem *et al.*, 2016; Utterback, 1994), and inter-firm collaborations are essential for gaining access to complementary assets required for new technology development (Ahuja, 2000; Hagedoorn, 2002; Lambe *et al.*, 1997).

Joint ventures

Harrigan (1988) suggested that rapid technological change, globalization and the blurring of the barriers between industries would lead to more JVs. Since the 1980s, the number of JVs has grown and the range of industries involved has increased (Kamminga *et al.*, 2007). A JV is a business agreement among multiple owners that establish a standalone entity (Harrigan, 1988). Kogut (1988, p. 319) suggests that "A joint venture occurs when two or more firms pool a portion of their resources within a common legal organization". Sometimes, a firm may opt for a spider's web of joint ventures wherein a firm may set up several alliances with different partners to achieve a strategic purpose (Harrigan, 1988). Unlike other forms of contractual partnerships, such as R&D contracts or joint development agreements, JVs, generally, are organizational units that are created and controlled by two or more parent firms (Hagedoorn, 2002), although some JVs are based on cooperation rather than shared ownership agreements (Harrigan, 1988). The type of JV arrangement depends on the industry's competitive setting (Harrigan, 1988). A JV can allow economies of scale and rapid acquisition of new resources, and can overcome trade barriers in foreign countries (Kamminga *et al.*, 2007). Rather than generating profits or increasing the customer base, a JV can be created to develop a new technology or allow entry to a new industry or market.

Alongside the benefits of a JV, the existence of multiple parent firms can lead to control issues (Kamminga *et al.*, 2007). Thus, JV success depends on the control structure among the parent firms (Kumar *et al.*, 1998). An appropriate control structure that aligns the JV's activities to the parent firms' strategies, will increase the parent firms' competitive advantage. For example, Gong *et al.*, (2007, p. 1022) suggest that, "In any joint venture, the structure and the process of exchange are the two central constructs affecting venture development and growth." Kumar *et al.* (1998) state that the parent firms' control depends on the degree of uncertainty in the environment and the strategic interdependence between the parent firm and the JV. Also, JVs with multiple owners are governed by contracts, which reduce the moral hazard and the potential for opportunistic behavior. Typically, a JV is in a hierarchical relationship with its parent firms, which, in turn, are involved in an interfirm relationship themselves (Kamminga *et al.*, 2007). Although JVs are a recognized way to organize business, their evaluation can be difficult since they tend to be set up in risky, uncertain business environments (Anderson, 1990).

Dominant design and standards

The dominant design is a specific path that firms in a particular industry take in order to establish an advantage over other design paths (Suárez *et al.*, 1995).The emergence of a new dominant design is considered to depend on technological, economic and organizational factors. The development of a new technology does not automatically lead to the establishment of a dominant design and they are not always based on a superior technology. A dominant design may be established for non-technical reasons, an example being the dominance of the QWERTY keyboard[2]. The establishment of a dominant design allows the firms to survive during periods of rapid technological change.

Dominant design, often, is related to standards. According to Brem (2016, p. 80), "The interrelation of standards, standardization, or dominant design and innovation seems to be a major contributor to a firm's competitiveness." However, the influence of standardization on innovation has been rather overlooked (Brem *et al.*, 2016). Suárez *et al.* (1995, p. 417) define standards as, "the result of a battle among different technical alternatives (such as different computer architectures)", which suggests that standards are based on technical paradigms although dominant design is not based solely on technology. When a dominant design is accepted as the industry standard (i.e., the dominant design is synonymous to a standard or personifies a collection of standards for a complex assembled product), non-technical factors, such as government interventions, industry regulation, network externalities, etc., play a major role. Government agencies can also regulate innovation activity by institutionalizing the dominant design as an industry standard. Inevitably, a dominant design based on a current technology is a major impediment to the adoption of a new technology. Hence, collaborations, in the form of strategic alliances or ecosystems, are essential since technological change

[2] The survival of QWERTY keyboard is largely due to the "presence of strong technical interrelatedness, scale economics and irreversibilities due to learning and habituation" (David, p. 336, 1985).

requires industry consensus on the adoption of a common new technology (Abernathy *et al.*, 1978; Brem *et al.*, 2016).

Innovation ecosystems

Value networks is gaining attention as a phenomenon wherein actors work together in developing and commercializing innovation (Gomes *et al.*, 2018; Peppard et al., 2006). The notion of ecosystem describes such a complex web of alliances. The term "ecosystems" has received tremendous attention recently and appears in many titles and abstracts in top strategy journals (Gomes *et al.*, 2018; Jacobides *et al.*, 2018; Oh *et al.*, 2016; Scaringella *et al.*, 2018). Jacobides *et al.* (2018, p. 2264) argue that "an ecosystem comprises of a set of actors with varying degrees of multilateral, non-generic complementarities that are not fully hierarchically controlled". The activities of the actors within an ecosystem are orchestrated by a keystone firm (also addressed as lead firm) to ensure that value is shared amongst the ecosystem participants (Clarysse *et al.*, 2014; Iansiti *et al.*, 2004; Jacobides *et al.*, 2018; Williamson *et al.*, 2012).

The notion of ecosystem is encompassed in more nuanced constructs such as business ecosystem, innovation ecosystem, business ecosystem, entrepreneurial ecosystem, etc. (Scaringella *et al.*, 2018). Jacobides *et al.* (2018) analysis of the ecosystem literature, identifies three main types of ecosystems: innovation, ecosystem business ecosystem and platform ecosystem. The innovation ecosystem focuses mainly on a particular innovation or value creation activities while the business ecosystem is focused more on value appropriation and the platform ecosystem involves a platform around which actors develop their solutions (Aarikka-Stenroos *et al.*, 2017; Adner, 2006, 2017; Gomes *et al.*, 2018; Jacobides *et al.*, 2018; Oh *et al.*, 2016). An innovation ecosystem enables the actors to access resources and complementary assets that would be beyond the scope and capabilities of a single actor (Adner *et al.*, 2010; Gawer *et al.*, 2014; Iansiti *et al.*, 2004; Kelly, 2015). Distinct to an innovation ecosystem is the presence of a technology platform over which firms combine their individual offerings to present a complete value proposition to the customer (Dattée *et al.*, 2018; Gawer *et al.*, 2014). In the traditional value chain, actors organize activities in a hierarchical buyer-seller relationships. However, in an innovation ecosystem, value is created in a network with shared assets, interfaces and standards (Dattée *et al.*, 2018; Jacobides *et al.*, 2018; Peppard *et al.*, 2006), in which all of the actors are important, for creating and delivering value simultaneously rather than sequentially.

The term innovation ecosystem is thus used to describe the value creation activities among the organizations connected to a keystone firm or platform in a non-linear system and includes both production and use side participants (Adner *et al*., 2010; Iansiti *et al*., 2004; Moore, 1993; Oh *et al*., 2016). Several scholars describe innovation ecosystem as capturing the complexity of innovation activity spanning industries and national boundaries (Adner *et al.*, 2010; Brusoni *et al.*, 2013). Jackson (2011, p. 2) defines an innovation ecosystem as 'complex relationships that are formed between actors and entities whose functional goal is to enable technology development and innovation'. According to Jacobides *et al.* (2018), an ecosystem is not a generic open system, but rather a network of actors with unique or supermodular complementarities.

Jacobides *et al.* (2018) discuss two types of complementarities that characterize the interactions among the actors in an ecosystem. The first are unique complementarities which means that A needs B in order to function (or value of A is maximized with B). This type of complementarities can also be generic in nature, that is, a good or service that all actors can easily access without any risks of misappropriation (Teece, 1986). For example, an Internal Combustion Engine (ICE) based vehicle needs gasoline to function, and manufacturers of these vehicles, and customers rely on the availability gasoline. The second type of complementarity is *supermodular complementarity* in which A and B are unique products or assets and more of A leads to B becoming more valuable (Jacobides *et al.*, 2018). An example of a supermodular complementarity is the Operating System (OS) for smartphones where the availability of apps on the OS platform increases the value for the end user. The non-generic nature of complementarities (i.e., supermodular complementarity) and the lack of hierarchical control distinguishes an ecosystem from other value creation mechanisms such as open innovation and R&D partnerships (Jacobides *et al.*, 2018).

METHOD

The context of the automotive industry

The increased use of embedded systems in modern vehicles, coupled with advancements in connectivity and information and communication technology (ICT) has shifted the innovation landscape in the automotive industry (Coronado Mondragon *et al.*, 2006; Townsend *et al.*, 2014). The industry is now approaching the next major transformation: *Autonomous Drive* (Yun *et al.*, 2016). AD technology has the potential to transform the entire automotive industry and alter today's transport infrastructure (Greenblatt *et al.*, 2015; Lee *et al.*, 2016; Yun *et al.*, 2016). Autonomous vehicles will be able to chauffeur people from one point to another without human intervention and will be technologically and socially disruptive (Greenblatt *et al.*, 2015). Many of the skills and competences related to chauffeuring as a business will become redundant in the future. The advent of autonomous vehicles is creating a space for firms outside the automotive industry to disrupt the entire industry. Yet, standards for vehicle safety along with established domain design pose a challenge for new technology adoption (Abernathy *et al.*, 1978; Anderson *et al.*, 1990; Yun *et al.*, 2016).

The AD technology developed by non-automotive firms who are outside the Own Equipment Manufacturer's (OEM's) traditional value chain pose a significant threat to the OEMs. Thus, incumbent firms in the automotive industry will need to interact with actors outside the industry to capture the required competences. However, collaboration for innovation involves some difficult issues: traditional automotive firms are entrenched in the value chain mode of operations. New technologies will need standards (and dominant design) that allows widespread adoption (Brem *et al.*, 2016). The 1908 Ford model T established a dominant design for the automotive industry that remains the standard for contemporary cars. However, lack of standards and/or the previous dominant design will be a barrier to the adoption of a new technology (Abernathy *et al.*, 1978; Anderson *et al.*, 1990). Thus, the setting of development of the AD technology in the automotive industry is considered a suitable case to study an emerging innovation ecosystem.

Research design

This paper is based on a longitudinal case study of an AD program[3] at Volvo. A single case design was chosen since the phenomenon is evolving within a real-life context (Eisenhardt, 1989; Eisenhardt *et al.*, 2007; Yin, 2009) and requires an exploratory approach. A single case study allows exploration of the dynamics of a phenomenon embedded in a complex relationship with its context. Also, a longitudinal study facilitates a deeper understanding of the specific context, that is, how various agents (people) and units (teams) interact and the reasons for their interactions. Staying close to the case as a participant observant over a long period of time, allowed proximity to the nucleus of the case (Mulhall, 2003). Data was collected ethnographically through observations, interviews and secondary sources. This type of data collection wherein the researcher is immersed in the case setting, as a 'participant as observer' can be described as an ethnographic method (Aktinson *et al.*, 1998; Anderson, 2009; Yin, 2009).

The study tracked activities taking place within the AD technology development initiative at Volvo. Due to the emergent and unique nature of the phenomenon, the empirical data and theory were revisited concurrently to better understand the context. By moving back and forth

[3] AD program began as an internal project at Volvo. Later, it was reorganized into a program.

between the empirical setting and the theory, our research design is in line with the systematic combining approach (Dubois *et al.*, 2002). Alongside the field activities, both authors were involved in regular discussions on the case in order to validate interpretations and identify striking elements. We also reviewed the literature to allow us to interpret our findings. This positions our study as abductive research (Dubois *et al.*, 2002).

Data collection and analysis

The paper builds on data collected from multiple sources between 2016 and 2019. Data were collected by one of the authors through observation, interviews, informal discussions, and archives which produced various types of qualitative data that can be described as ethnographic data (Yin, 2009). The presence at the case firm allowed familiarization with various activities and identification of aspects not revealed by the interviews, surveys or other ex-post investigative techniques). Observation data were useful to identify nonverbal activities, such as who interacts with whom and how actors communicate with each other, and to catalogue events as they unfolded (Kawulich, 2005).

The data collected include some 650 pages of field notes on observation of numerous weekly meeting with important stakeholders, Program Increment (PI) planning events (the agile working method was adopted in 2018), shadowing two senior managers for a week each and photos from white board discussions with key stakeholders. Further, 25 semi-structured interviews were also conducted to confirm interpretations from field observations and clarify inconsistencies. The field notes were reviewed and coded using X-mind mapping software for phase A and data analysis software NVivo for phases B and C (see Table 1).

The rich data required a structured data analysis process. Gioia *et al.* (2013) express that it is ‘quite normal’ to feel ‘lost’ in the data analysis process. The data collection was made in three phases between November 2016 and June 2019, as summarized in table 1. In Phase A, the field notes were handwritten in a diary. The handwritten notes were mapped using Xmind mapping software to identify patterns and changes over time. To deepen the analysis, digital notes were taken during phases B and C and these notes were exported to NVivo, which allowed for word searches and data clustering.

‘Insert table 1 here’

To further structure the data, we applied the Gioia method (Gioia et al., 2013). Table 2 depicts the sequence of the data clustering. Statements, which identified the key aspects of the AD program, were identified in the three data collection phases. Comments made by personnel at Volvo led to first order statements which were then clustered under second order categories. Patterns in the second order categories were identified, and were aligned to three aggregate dimensions:

i) Resource and competence

ii) Commercialization

iii) Modularization

See example of the analysis in Table 2 below

‘Insert table 2 here’

The results of the study were validated through informal discussions with key people in Volvo, to confirm our emerging findings.

VOLVO CARS' AUTONOMOUS DRIVE PROGRAM

The AD program

Volvo is a Swedish car manufacturer that is considered one of the market leaders in the area of safety (Liu *et al.*, 2004). In recent years, Volvo has expressed interest in developing AD and has invested hugely in an AD program (VolvoCars, 2019a, 2019b). Volvo's strong safety and Advanced Driver Assistance Systems (ADAS) record makes development of AD technology a natural step for the firm. It is involved in several collaborations in the area of AD that include non-automotive firms in Sweden and internationally. The main purpose is to develop AD technology alongside the software and hardware systems required to produce a fully autonomous car (VolvoCars, 2019b).

Volvo's AD program is based on three main research initiatives: the Drive Me project (a research initiative); Zenuity (a JV with Veoneer,) and the Uber project (redundant car platform[4]). Drive Me involves several research platforms where Volvo collaborates with various partner organizations to develop autonomous cars for an urban environment, focusing on safety, traffic flow and energy efficiency (Victor *et al.*, 2017). Drive Me allows Volvo to engage with both public and private actors beyond its traditional value chain.

Zenuity is an ADAS and AD software development firm that was created as a JV between Volvo and Veoneer (VolvoCars, 2019a). Veoneer (a spin-off from Autoliv) is a major automotive supplier with expertise in the area of Safety Electronics, ADAS, and AD. Zenuity was launched in spring 2017 and is owned 50-50 by Volvo and Veoneer. The firms combined their intellectual property, know-how and personnel to form the JV (Volvo Cars, 2017a, 2017b). Many personnel from Volvo's safety division moved to Zenuity. Despite the shared ownership, Zenuity is an independent firm and positions itself as an AD and ADAS software supplier (Zenuity, 2018). The AD and ADAS software solutions were developed in close collaboration

[4] A redundant system consists of two or more independent system that is intended to achieve safety goals. Highly Automated Driving (HAD) requires redundant systems to ensure safety.

with Volvo and are commercialized through Veoneer. Through the JV partnership with Veoneer, Volvo's AD program expects to acquire new resources and competences in the area of automotive safety.

The Uber project involves delivery of base vehicles that have the required safety, redundant system and core autonomous driving technology (VolvoCars, 2016). Uber is the global leader in the ride-sharing transport business and is a new partner for Volvo. According to the CEO of Volvo, the Uber partnership is in line with Volvo's intention to be a supplier of AD ride-sharing services globally (VolvoCars, 2017b). The CEO believes that the alliance with Uber positions Volvo at the heart of the technological revolution taking place in the automotive industry (VolvoCars, 2016).

Volvo has also launched several other new initiatives related to its AD program (VolvoCars, 2018a). For instance, it signed a partnership agreement with Baidu in 2018 to develop electric and fully autonomous cars for the Chinese market (VolvoCars, 2018b). The complexity of technology means that, Volvo's AD program, which initially was an internal project, has developed into a continuous development program with new collaborations over time (see table 3).

'Insert table 3'

The rationale for inter-firm collaboration

During fieldwork of the AD program, several people told us that automotive firms are being increasingly challenged by technology firms with critical competences in software development and artificial intelligence (AI). Employees working at both Volvo and Zenuity believed that, in order to stay competitive, it was necessary to obtain new resources and competences, especially in the area of software development. One interviewee described that:

> "It is about resources […] if we are going to be part in the game, we need to double up or triple up our resources."

Many of the collaborative initiatives in the AD program were described as motivated by resources or competence requirements. Also, a person on the business side of the autonomous cars program, said that technology development, on its own, will not be enough to commercialize them. In addition to resource and competence enhancing collaborations, he underlined that initiatives, such as Drive Sweden, , were needed to allow participation in policy making and discussions about autonomous mobility regulation. Drive Sweden is a Strategic Innovation Program funded by several Swedish institutions to support the development of sustainable mobility. Volvo engages with actors outside the automotive industry, in order to ensure progress in all areas related to AD technology – including infrastructure, legislation, safety standards, etc. Commercialization is an important driver of these inter-firm partnerships.

The AD program involves various collaborations, each with a distinct purpose, but contributing towards the overall goal. The interviews and field observations showed that all the activities in the AD program were centered around three aspects:

1. *Competences* — in the area of sensor fusion, machine learning, and active safety.
2. *Resources* — in the form of investments, knowledge, etc.
3. *Commercialization* —appropriate value from AD vehicles.

The field observations also showed that most collaborations were interconnected. For instance, the Drive Me project provided an interface with government agencies, academia and other technology firms. The collaboration with Uber enabled Volvo to share development of the base car with redundancy and electrical software architecture (Forbes, 2017). Volvo's base car will be used by Uber to develop its own self-driving system. A senior manager explained that the collaboration with Uber gave Volvo access to commercialization opportunities in the ride sharing market.

These collaborations, which extend beyond Volvo's traditional value chain, are seen by many employees as a sign of a changing innovation trajectory in the industry. This is illustrated in a quote from a senior manager at Volvo:

> "If you look at the car industry today, we do not own our value chain […] what we see for the future, the value chain management will change. Locked together with AD but also with electrification and fleet".

The need to coordinate tasks and routines: Bottlenecks and interdependencies

The complexity of the AD technology means that firm collaborations are essential. However, transferring software development to Zenuity made the AD program dependent on an external firm for the AD software. The AD program, which began as an internal project, is now dependent on external partners. Despite being part-owned by Volvo, discussions with Zenuity need to be formalized. According to employees at Volvo, this created bottlenecks, for example:

> "[on Zenuity being an independent firm] It's hard now […] it's a different company and sitting at different location […] harder when you are away from each other than to just walk by and discuss[…]to go up a floor and then discuss issues[…]we are a separated in different areas in Gothenburg […]we (might) build our misunderstanding on the lack of communication."

AD software development is centered around artificial intelligence (AI) and machine learning, which typically involves collection and processing of data from a suite of sensors such as Radar, Lidar, etc. The interdependence between Volvo and Zenuity raised new problems pertaining to coordinating tasks between the two firms. Volvo relies on Zenuity to supply the software stack for the AD technology while Zenuity depends on Volvo to provide the development vehicle to collect the data, test its AD software and carry out other machine learning tasks. Many employees expressed that the interdependence slowed the pace of innovation. Some managers, nevertheless, said that externalizing software development was a good move since it increased the rate of software development and allowed the software to be sold to other OEMs in the industry.

Despite the advantages, some managers felt that spinning out AD and ADAS software development to Zenuity had created problems related to coordinating and synchronizing development activities. Field observations also revealed that they were concerned about the poor flow of information between Volvo and Zenuity. In the weekly meetings, many employees expressed frustration due to the lack of coordination between Volvo and Zenuity, as the following extracts show:

> "Lots of things happening in the organization and its difficult to know [about it]"
>
> "We need to have a common understanding [with other stakeholders]"
>
> "It is a different kind of project compared to anything we have done before [On the AD technology development]"
>
> "We do not know what is going on […] a lot going on at the top level […]but what is happening with Zenuity?"

This frustration affected other collaborations related to the AD program. To ensure compatibility with Zenuity's AD software, some important decisions made by Volvo which affected the adoption of technology standards or the selection of components, had to be coordinated with Zenuity. For example, when Volvo wanted to use a certain firm as its map supplier, it was challenged by Zenuity's preference for a different firm. In essence, Volvo had to adapt its systems to facilitate integration with Zenuity's software stack and components and systems from other technology firms such as Uber, Nvidia, etc. The following quote from a senior manager is illustrative:

> "We need to be modular because someone like *Firm A* would not want to be involved *with Firm B*. So, we need to think about this as well"

Volvo and Zenuity also had different ways of working. Volvo, similar to other manufacturing and automotive firms, was based on a traditional waterfall method, while Zenuity, similar to other software firms, preferred the agile method. This was perceived to impede the coordination of work between the firms. In order to align its operations to those of its partner firms, especially Zenuity, at the beginning of 2018, Volvo's AD program began to shift from a waterfall to an agile way of organizing work. Managers believed that this would facilitate cross-functionality and flexibility in the development process.

ANALYSIS AND DISCUSSION

Collaborations in the AD program

Volvo's decision to establish a JV was due largely to the complexity of the AD technology which required competencies in the field of AI, sensor systems, communication networks, cloud computing, etc. While inter-firm collaborations, such as JVs or other partnerships, are useful mechanisms to accumulate new competences and resources, they are seldom able to commercialize the technology (Brem *et al.*, 2016). A superior technology neither creates a new standard nor yields economic benefits to the actor developing the technology (Brem *et al.*, 2016) and new technologies and platforms seldom emerge without the contribution of complementary innovations (Brem *et al.*, 2016; Gawer *et al.*, 2014). In the case of AD technology, current industry standards, regulation, transport infrastructure, etc. do not facilitate commercialization of AD vehicles. In addition to finding ways to access the additional resources and competences required to build the AD technology, Volvo engages with numerous actors, such as traffic authorities, emergency services, government agencies, etc., to participate in policy making and setting the regulations related to autonomous cars.

Thus, Volvo engages with various actors through collaborative initiatives to push for regulations and standards for autonomous vehicles. Also, collaborations with firms such as

Nvidia, Uber, Baidu, etc., enhance Volvo's prospects of commercializing its autonomous cars. This is in line with literature on standardization, which discusses the importance of firms cooperating over the development of innovations in the context of technology platforms (Brem *et al.*, 2016). Figure 1 shows that, over a period of two years, Volvo increased the number of its collaborative initiatives. The AD program began as an internal innovation 'project' and spiraled into a 'program' consisting of several bi-lateral and multi-lateral collaborations. All collaborations are based on the AD base car developed by Volvo.

Modularity through a 'symbiotic' joint venture

The literature on interfirm collaborations emphasizes the benefits from pooling resources via a JV (Gong *et al.*, 2007). Establishing Zenuity in partnership with Veoneer is in line with the literature on inter-firm collaborations (Adner *et al.*, 2010; Ahuja, 2000; Gawer *et al.*, 2014b; Hagedoorn, 2002; Teece, 1986a). However, previous work on JVs describes the relation between the parent firms and the JV as one of the parents exercising control over the JV in a hierarchical relationship JV (Hagedoorn, 2002). Zenuity is an independent firm, which must seek customers for its AD software solution without giving priority to Volvo. Interestingly, the other JV parent, Veoneer is the exclusive supplier and distributor of Zenuity's products to other actors (except Volvo who can directly source from JV) (VolvoCars, 2017a). Volvo and Veoneer transferred parts of their active safety units, including the intellectual property and personnel, to Zenuity (VolvoCars, 2017a). This was a momentous decision for Volvo, whose reputation has been built on safety, which is considered a core competence of the company. In contrast to traditional JVs, where the JV is independent of the core business, AD technology development at Volvo depends on Zenuity's ability to deliver the software. Also, Zenuity aims to be a software supplier for all OEMs, not just Volvo. This has significant implications since the hardware system (developed by Volvo) and software system (developed by Zenuity) needs to be integrated in the AD program. This raises system integration problems common to complex product projects (Madni *et al.*, 2014). Thus, outsourcing the software development to Zenuity rather than retaining inhouse, implicitly resulted in a modular system that can be used by other actors to develop complementary products.

We argue that the interdependence created between the firms resembles what Davis *et al.* (2011) describe as a *symbiotic relationship*. Davis and Eisenhardt describe that the main issue involved in symbiotic relationships is alignment of R&D efforts towards a common goal without self-interest. In the JV literature (Anderson, 1990; Davis *et al.*, 2011; Garcia-Pont *et al.*, 2002; Hill *et al.*, 1994; Kamien *et al.*, 1992; Kogut, 1988; Kumar *et al.*, 1998; Williamson *et al.*, 2012), there is no mention of symbiotic relationships between a parent firm and joint venture wherein the parent's core product or service is dependent upon the success of the JV. Based on this case study, we propose that a JV set up with a strong interdependence between the parent firm and the JV can be described as a *symbiotic JV*.

This symbiotic relationship led Volvo not to reconcile with a closed technology platform. The case study shows how Volvo established a JV to bundle the resources and competences needed to develop the technology platform. This implicitly led to modularization of the technology due to the strong interdependencies between the JV and Volvo. The modularity facilitated the inclusion of other actors developing complementary products, which increased the attractiveness of Volvo's innovation ecosystem over competing ecosystems.

Emergence of an innovation ecosystem

Technology and market attractiveness are crucial for the widespread adoption of an innovation (Gawer *et al.*, 2008). Commercialization of AD technology is dependent on the development of complementarities. Thus, Volvo had to engage in collaborations beyond the JV to commercialize the technology. The development of a modular technology made it easier for Volvo to a establish new collaborations. Thus, over time, Volvo was involved in a network of collaborations, all aimed at facilitating commercialization of the core technology (See figure

1). This network of collaborations in the AD program is akin to an innovation ecosystem where actors collaborate with each other in order to develop value surrounding a technology platform (Adner, 2017; Clarysse *et al.*, 2014; Furr *et al.*, 2018; Gawer *et al.*, 2014b; Gomes *et al.*, 2018; Jacobides *et al.*, 2018).

'Insert figure 1 here'

Among these inter-firm collaborations, the AD program at Volvo was at the core of the emerging innovation ecosystem . Any new technology needs to be integrated with a product for the end customer to perceive value and ecosystems generally need a core technology platform over which firms create value for the end customer (Gawer *et al.*, 2014). Also, literature on ecosystems acknowledge the importance of a 'keystone' firm in integrating the solutions developed by other firms on the platform and to ensure survival of the ecosystem (Iansiti *et al.*, 2004; Jacobides *et al.*, 2018). Actors like Uber, Baidu, Nvidia etc. had significant know-how and competences. Yet, Volvo being the parent firm (of Zenuity) and the developer of the base car has a unique role as the integrator of AD technology with the product (i.e., car). Thus, in this emergent innovation ecosystem, Volvo takes the role of the keystone firm (Iansiti *et al.*, 2004).

To strengthen the ecosystem and its keystone position, Volvo needs to ensure that its technology is attractive to other firms developing complementary services. Work on innovation platforms and ecosystems highlights the role of the keystone firm for ensuring platform modularity and coordinating activities in the ecosystem (Brem *et al.*, 2016; Gawer *et al.*, 2014a; Iansiti *et al.*, 2004). Although ecosystems, especially those built on software platforms, are new for the automotive industry, they have been investigated in the case of other industries. For example, the Open Handset Alliance established by Google with handset makers for its Android mobile platform is a good illustration of a software platform-based ecosystem. The success of the Android ecosystem is attributable largely to Google's ability to attract handset makers, network operators, application developers, etc. to its software platform. Likewise, due to Zenuity's focus on developing software for all OEMs, the AD program is well positioned to attract a multitude of actors to the ecosystem. Thus, the formation of Zenuity to commercialize AD software to all OEMs inevitably made Volvo opt for a modular system (See figure 2). Many of the features had to be developed with suppliers who worked with the entire ecosystem of actors not just Volvo.

'Insert figure 2' here

LEVERAGING THE JV TO BECOME A KEYSTONE FIRM

Collaborations in new technology development

This paper set out to create a better understanding of the emergence of new innovation ecosystems by investigating the nature of collaborations in new technology development initiatives. By analyzing various inter-firm collaborations at the case firm, we find that that the collaboration was primarily motivated by the resource and competence needs of the technology under development. Amongst several collaborations, a JV set up by the case firm (of our study) was particularly interesting. The JV had a symbiotic relationship with its parent firm (i.e., the case firm). This JV is addressed in our paper as a 'symbiotic JV' due to its unique characteristics compared to traditional JV (Kogut, 1988; Kumar *et al.*, 1998; Zhang *et al.*, 2007).

Becoming A Keystone Firm: Symbiotic JV And Innovation Ecosystem

Literature on ecosystems highlight that the modularity in a technology platform is fundamental to the emergence of an ecosystem (Cusumano et al., 2002; Jacobides et al., 2018).

Modularity facilitates new partnerships and help establish a network of actors who can develop complementarities and push for establishment of standards for the new technology. We have shown that the development of a modular technology can be supported by a symbiotic JV. The ability to attract actors able to develop products or services to complement the new technology is vital for the adoption of new technology; as dominant design of previous technology and complementarities pose significant hurdles for new technologies. Thus, the firm that is capable of developing a modular technology that allows other firms to develop complementarities is key to the emergence of an ecosystem (Jacobides *et al.*, 2018).

We find that the symbiotic JV had a dual impact on the technology development project. Firstly, it secured the resources and competences for the parent firm to develop the new technology, in line with literature on JV (Gong et al., 2007; Hagedoorn, 2002; Kumar et al., 1998). Secondly, it led to the development of a modular system which attracted other actors developing complementarities (Gawer *et al.*, 2014a; Jacobides *et al.*, 2018). This is due to the parent firm's dependence on the JV for its technology development and the JV's ambition to be a supplier to all firms and not just its parent firm. This implicitly resulted in a modular technology and in turn nurtured the emergence of the ecosystem. Also, the parent firm's ownership of a modular technology platform enhanced its ability to become a keystone firm in the emerging innovation ecosystem. Thus, the establishment of the JV with a symbiotic relationship to the parent firm implicitly supported the parent firm to become a keystone firm.

Innovation ecosystem as a way to commercialize new technology

An innovation ecosystem accelerates the adoption of a new technology by facilitating the development of standards and complementarities, often attributed to be the biggest impediment for new technology commercialization (Adner et al., 2010; Oh et al., 2016). Previous studies of ecosystems have acknowledged the lack of understanding of the emergence of ecosystems

(Adner *et al.*, 2016; Gawer *et al.*, 2014b; Jacobides *et al.*, 2018), partly due to the difficultly in tracing the origins of an ecosystem before the fact. Also, ecosystem literature has underlined the importance of modularity in facilitating the development of complementary products and services, implying that modularity lays the foundation for the emergence of a new ecosystem.

In our study, we show that the challenges related to standards and complementarities motivated the keystone firm to engage with other actors. Lack of standards and complementarities also pose a hurdle to commercializing the new technology. In order to attract actors towards its technology, the case firm had to nurture a new ecosystem and position itself as a keystone firm. This was achieved by its symbiotic JV. Modularity can be difficult to achieve and many firms find the endeavour cumbersome and fruitless. In our case study, we show that the establishment of a symbiotic JV (although aimed initially at augmenting resources and competence) pushed the keystone firm to build a modular system.

CONCLUSION

This paper set out to explore collaborations in a mature industry during a time of technological change. The paper described how incumbent firms secure resources and competences to develop a new technology. In discussing the various collaborations, we shed light on the emergence of a new innovation ecosystem and the role of the keystone firm in its construction.

Through the case study, we showed that the establishment of a symbiotic JV pushed the parent firm to build a modular technology platform upon which other actors could develop complementarities and also facilitate work towards standardization. This transformed the parent firm of the symbiotic JV into a keystone firm and led to the emergence of an innovation ecosystem. The present paper contributes to academic work on innovation ecosystems by shedding light on the role of a symbiotic JV in the emergence of an innovation ecosystem.

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.

Abernathy WJ, Utterback JM. 1978. Patterns of industrial innovation. *Technology Review* **80**(7): 40-47.

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.

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

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.

Ahuja G. 2000. The Duality of Collaboration: Inducements and Opportunities in the Formation of Interfirm Linkages. *Strategic Management Journal* **21**(3): 317-343.

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

Anderson E. 1990. Two Firms, One Frontier: On Assessing Joint Venture Performance. *Sloan Management Review* **31**(2): 19.

Anderson K. 2009. Ethnographic research: A key to strategy. *Harvard Business Review* **87**(3): 24.

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

Bergek A, Tell F, Berggren C, Watson J. 2008. Technological capabilities and late shakeouts: Industrial dynamics in the advanced gas turbine industry, 1987-2002. *Industrial and Corporate Change* **17**(2): 335.

Brem A, Nylund PA, Schuster G. 2016. Innovation and de facto standardization: The influence of dominant design on innovative performance, radical innovation, and process innovation. *Technovation* **50-51**: 79-88.

Brusoni S., & Prencipe, A. 2013. The Organization of Innovation in Ecosystems: Problem Framing, Problem Solving, and Patterns of Coupling. *Advances in Strategic Management, **30**, 167*-194.

Chesbrough H. 2010. Business Model Innovation: Opportunities and Barriers. *Long Range Planning* **43**(2): 354-363.

Christensen CM, Rosenbloom RS. 1995. Explaining the attacker's advantage: Technological paradigms, organizational dynamics, and the value network. *Research Policy* **24**(2): 233-257.

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.

Coronado Mondragon CE, Coronado Mondragon AE, Miller R. 2006. Modularity, open architecture and innovation: an automotive perspective. *International journal of automotive technology and management* **6**(3): 346-363.

Cusumano MA, 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 JP, Eisenhardt KM. 2011. Rotating Leadership and Collaborative Innovation:Recombination Processes in Symbiotic Relationships. **56**(2): 159-201.

Dubois A, Gadde L-E. 2002. Systematic combining: an abductive approach to case research. *Journal of Business Research* **55**(7): 553-560.

Eisenhardt KM. 1989. Building Theories from Case Study Research. *The Academy of Management Review* **14**(4): 532-550.

Eisenhardt KM, Graebner ME. 2007. Theory Building from Cases: Opportunities and Challenges. *The Academy of Management Journal* **50**(1): 25-32.

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

Garcia-Pont C, Nohria N. 2002. Local versus global mimetism: the dynamics of alliance formation in the automobile industry. **23**(4): 307-321.

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

Gawer A, Cusumano MA. 2014. Industry Platforms and Ecosystem Innovation. *Journal of Product Innovation Management* **31**(3): 417-433.

Gioia DA, Corley KG, Hamilton AL. 2013. Seeking Qualitative Rigor in Inductive Research:Notes on the Gioia Methodology. **16**(1): 15-31.

Gomes LAdV, Facin ALF, Salerno MS, Ikenami RK. 2018. Unpacking the innovation ecosystem construct: Evolution, gaps and trends. *Technological Forecasting and Social Change* **136**: 30-48.

Gong Y, Shenkar O, Luo Y, Nyaw M-K. 2007. Do multiple parents help or hinder international joint venture performance? The mediating roles of contract completeness and partner cooperation. **28**(10): 1021-1034.

Greenblatt JB, Saxena S. 2015. Autonomous taxis could greatly reduce greenhouse-gas emissions of US light-duty vehicles. *Nature Clim. Change* **5**(9): 860-863.

Hagedoorn J. 2002. Inter-firm R&D partnerships: an overview of major trends and patterns since 1960. *Research Policy* **31**(4): 477-492.

Hagedoorn JJSmj. 1993. Understanding the rationale of strategic technology partnering: Nterorganizational modes of cooperation and sectoral differences. **14**(5): 371-385.

Harrigan KR. 1988. Joint ventures and competitive strategy. **9**(2): 141-158.

Henderson RM, Clark KB. 1990. Architectural Innovation: The Reconfiguration of Existing Product Technologies and the Failure of Established Firms. *Administrative Science Quarterly* **35**(1): 9-30.

Hill RC, Hellriegel D. 1994. Critical Contingencies in Joint Venture Management: Some Lessons from Managers. *Organization Science* **5**(4): 594-607.

Hobday M, Rush H. 1999. Technology management in complex product systems (CoPS) - ten questions answered. *International Journal of Technology Management* **17**(6): 618-638.

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

Jackson DJ. 2011. What is an innovation ecosystem. *National Science Foundation* **1**.

Jacobides MG, Cennamo C, Gawer A. 2018. Towards a theory of ecosystems. *Strategic Management Journal* **39**(8): 2255-2276.

Johansson M, Axelson M, Enberg C, Tell F. 2011. Knowledge Integration in Inter-firm R&D Collaboration: How do Firms Manage Problems of Coordination and Cooperation. *Knowledge Integration & Innovation–Critical Challenges Facing International Technology-based Firms*: 148-169.

Kamien MI, Muller E, Zang I. 1992. Research Joint Ventures and R&D Cartels. *The American Economic Review* **82**(5): 1293-1306.

Kamminga PE, Van der Meer-Kooistra J. 2007. Management control patterns in joint venture relationships: A model and an exploratory study. *Accounting, Organizations and Society* **32**(1): 131-154.

Kawulich BB. Year. Participant observation as a data collection method. In Proceedings of the Forum Qualitative Sozialforschung/Forum: Qualitative Social Research.

Kelly E. 2015. Introduction: Business ecosystems come of age. *Business Ecosystems Come of Age. IFIP* **243**: 399-406.

Klepper S. 1997. Industry Life Cycles. *Industrial and Corporate Change* **6**(1): 145-182.

Kogut B. 1988. Joint Ventures: Theoretical and Empirical Perspectives. *Strategic Management Journal* **9**(4): 319-332.

Kumar S, Seth A. 1998. The Design of Coordination and Control Mechanisms for Managing Joint Venture-Parent Relationships. *Strategic Management Journal* **19**(6): 579-599.

Lambe CJ, Spekman RE. 1997. Alliances, External Technology Acquisition, and Discontinuous Technological Change. **14**(2): 102-116.

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).

Liu H, Roos L-U, Wensley R. 2004. The dynamics of business orientation: the case of the Volvo Car Corporation. *Industrial Marketing Management* **33**(4): 333-344.

Madni AM, Sievers M. 2014. Systems integration: Key perspectives, experiences, and challenges. *Systems Engineering* **17**(1): 37-51.

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

Mulhall A. 2003. In the field: notes on observation in qualitative research. *Journal of Advanced Nursing* **41**(3): 306-313.

Oh DS, Phillips F, Park S, Lee E. 2016. Innovation ecosystems: A critical examination. *TECHNOVATION* **54**: 1-6.

Peppard J, Rylander A. 2006. From Value Chain to Value Network. *European Management Journal* **24**(2): 128-141.

Scaringella L, Radziwon A. 2018. Innovation, entrepreneurial, knowledge, and business ecosystems: Old wine in new bottles? *Technological Forecasting and Social Change* **136**: 59-87.

Suárez FF, Utterback JM. 1995. Dominant Designs and the Survival of Firms. *Strategic Management Journal* **16**(6): 415-430.

Teece DJ. 1986. Profiting from technological innovation: Implications for integration, collaboration, licensing and public policy. *Research Policy* **15**(6): 285-305..

Townsend JD, Calantone RJ. 2014. Evolution and Transformation of Innovation in the Global Automotive Industry. *Journal of Product Innovation Management* **31**(1): 4-7.

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.

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

Utterback JM, Suarez FF. 1993. Innovation, competition, and industry structure. *Research Policy* **22**(1): 1-21.

Victor T, Rothoff M, Coelingh E, Ödblom A, Burgdorf K. 2017. When Autonomous Vehicles Are Introduced on a Larger Scale in the Road Transport System: The Drive Me Project. In *Automated Driving: Safer and More Efficient Future Driving.* Watzenig D, Horn M (eds.), Springer International Publishing: Cham.

VolvoCars. 2016. Volvo Cars and Uber join forces to develop autonomous driving cars. *Volvo Car Group.* https://www.media.volvocars.com/global/en-gb/media/pressreleases/194795/volvo-cars-and-uber-join-forces-to-develop-autonomous-driving-cars [14 May 2019].

VolvoCars. 2017a. Volvo cars and Autoliv autonomous driving joint venture zenuity starts operations. *Volvo Car Group.* https://www.media.volvocars.com/global/en-gb/media/pressreleases/207309/volvo-cars-and-autoliv-autonomous-driving-joint-venture-zenuity-starts-operations [17 March 2019].

VolvoCars. 2017b. Volvo Cars to supply tens of thousands of autonomous drive compatible cars to Uber. *Volvo Car Grou.* https://www.media.volvocars.com/global/en-gb/media/pressreleases/216738/volvo-cars-to-supply-tens-of-thousands-of-autonomous-drive-compatible-cars-to-uber [14 May 2019].

VolvoCars. 2018a. Looking further ahead than ever before. *Volvo Car Group*. https://group.volvocars.com/news/future-mobility/2018/luminar [14 May 2019].

VolvoCars. 2018b. Volvo Cars and Baidu join forces to develop and manufacture autonomous driving cars. *Volvo Car Group.* https://www.media.volvocars.com/global/en-gb/media/pressreleases/240303/volvo-cars-and-baidu-join-forces-to-develop-and-manufacture-autonomous-driving-cars [16 July 2019]

VolvoCars. 2019a. Autonomous Drive. *Volvo Car Group.* https://group.volvocars.com/company/innovation/autonomous-drive [16 July 2019]

VolvoCars. 2019b. The Future of Driving. *Volvo Car Group*. https://www.volvocars.com/intl/buy/the-future-of-driving [16 July 2019].

Wernerfelt B. 1984. A Resource-Based View of the Firm. *Strategic Management Journal* **5**(2): 171.

Williamson PJ, De Meyer A. 2012. Ecosystem Advantage: How to Successfully Harness the Power of Partners. *California Management Review* **55**(1): 24-46.

Yin RK. 2009. *Case study research: design and methods*. SAGE: London.

Yun JJ, Won D, Jeong E, Park K, Yang J, Park J. 2016. The relationship between technology, business model, and market in autonomous car and intelligent robot industries. *Technological Forecasting And Social Change* **103**: 142-155.

Zenuity. 2018. Make it real. *Zenuity*. https://www.zenuity.com/make-it-real/#our-mission. [18 July 2019].

Zhang Y, Li H, Hitt MA, 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.

Table 1. Timeline of data collection activities

Phase	Time period	Firms	Type of data	Purpose of data collection	Data analysis	Author's activity
A	Nov 16 – Feb 18	Volvo Cars, Zenuity	Interviews, field notes	Understand the joint venture between Veoneer and Volvo	Mind map	Open-ended interviews, Participant as observer
B	Feb18- June 18	Volvo	Interviews, shadowing managers and field notes	Track the changes in way of working and new collaborations	NVivo coding	Participant as observer
C	June 18- June 19	Volvo	Interviews and Field notes	Follow the agile teams to understand daily activities and planning in SAFe	NVivo coding	Participant as observer

Table 2. Data analysis

1st order statements	2nd order categories	Aggregate dimension
You need to secure business […] that means you need a lot of revenue strategy and making external collaboration	Desire to collaborate	ii
(On Zenuity) First thing, be quicker […]find faster way to develop software […].So it's better to try to do it in a separate company. Second, cost of resources[…].we need to find a partner to do that'	Need to be the first in developing the technology	i
We see that we need to work together with society…need to find test beds…and Drive Sweden is a good example to build up these projects	Establishing confidence for the technology (amongst customers)	ii

We need to be modular because someone like *Firm A* would not want to be involved with *Firm B*. So, we need to think about this as well	Modularity to facilitate collaborations	iii
HAD program is part of AD ART Starting today, AD ART and had unit program are more or less the same	Shift from unit program structure to Agile Release Train (ART)	
On having multiple supplier: The solution we have is in the cloud […] We can have multiple supplier [*but*] we don't need to change in the car but in the cloud	Accommodate multiple suppliers or partners	iii
We have something in flow (an information sharing platform) to work with Zenuity. Whether it works or not is another thing.	Need for coordination	i & iii
We need to understand …and communicate with other interfaces.	Integration challenges	iii
If we going to be part in that game, we need to double up or triple up our resources.	Resource needs	i
On Drive Sweden: you need a business in it… you cannot always have test beds all the time, to make it happen, you need the business side of it… to get the economy together	Business needs	ii

Table 3. Timeline of important events in the AD program (Source: authors)

2013	Drive Me
2016	Uber partnership
2017	Launch of Joint Venture partnership with Veoneer
2018	Volvo Cars Tech Fund invests in Luminar – a start-up developing advanced sensor technology for autonomous vehicles
2018	NVIDIA partnership
2018	Baidu partnership

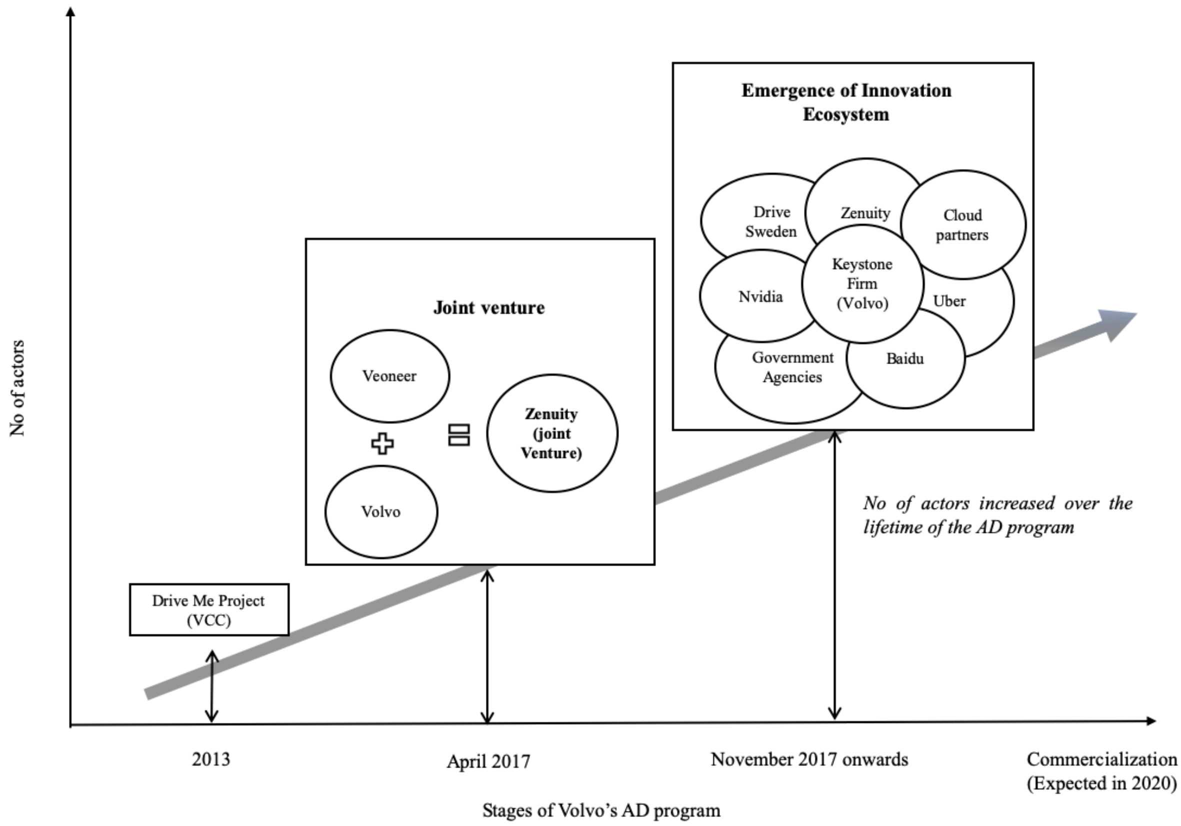

Figure 1. Timeline showing the emergence of an innovation ecosystem

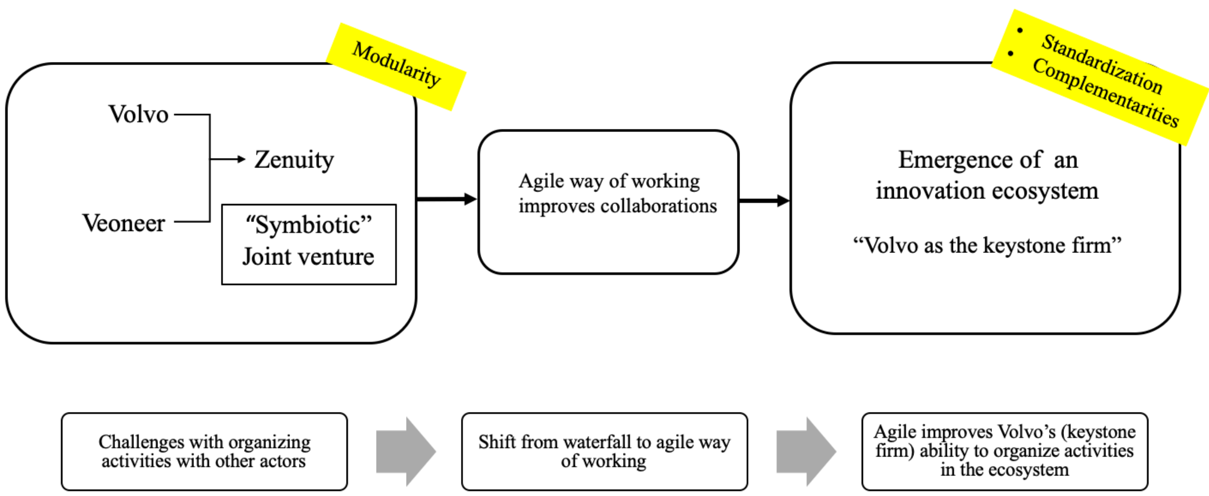

Figure 2. From a 'Symbiotic' Joint Venture to an Innovation Ecosystem