Shared Platform Evolution

Shared Platform Evolution

An Imbrication Analysis of Coopetition and Architecture

Fatemeh Saadatmand

Department of Applied Information Technology
University of Gothenburg

UNIVERSITY OF GOTHENBURG

Gothenburg 2018

Cover illustration: Catharina Jerkbrant

تقدیم به پدر و مادر عزیزم

To my dear parents

Shared Platform Evolution

An Imbrication Analysis of Coopetition and Architecture

Fatemeh Saadatmand

Department of Applied Information Technology
University of Gothenburg
Göteborg, Sweden

ABSTRACT

Shared platforms are a stable foundation for the integration of digital components by heterogeneous actors. These platforms are an emergent organizational form whose members seek interoperability of their IT systems through technological architectures constituted of a modular core, a standardized interface, and complementary extensions. Although extant Information Systems (IS) research on such platforms primarily emphasizes the social aspects of platforms, e.g., the economic dimension of platform members' positions vis-à-vis competitors and complementors, there is a growing literature that also takes their material aspects into account. In this dissertation, my objective is to contribute to this trend in sociomaterial theorizing of platforms by undertaking an imbrication analysis of a twelve-year shared platform initiative in the Swedish Road Haulage industry. Hence, I attempt to answer the following research question: "How do the participants' coopetitive behavior and the platform's technology architecture reciprocally shape the evolution of a shared platform?" My dissertation identifies three organizational forms that are likely to emerge in the evolution of a shared platform and assesses their respective implications for platform innovation. I conclude by articulating the contributions of my study to IS research and practice.

Keywords: Coopetitive behavior, imbrication lens, organizational forms, technology architecture, shared platform, standardized interface

SAMMANFATTNING PÅ SVENSKA

Delade digitala plattformar har potential att utgöra en stabil grund för integration av olika slags aktörer och deras IT system. Dessa plattformar är en allt vanligare organisationsform vars medlemmar eftersträvar interoperabilitet genom teknologiska arkitekturer, vilka består av en modulär kärna, ett standardiserat gränssnitt samt applikationer och funktionalitet. Den dominerande forskningen inom informatik betonar framför allt sociala aspekter relaterade till sådana plattformar, t.ex. den ekonomiska dimensionen som är avhängig medlemmars positioner gentemot varandra som både konkurrenter och samarbetspartners. Dock finns kompletterande forskning som på senare tid poängterat betydelsen av att studera tekniska aspekter och deras konsekvenser för plattformars utveckling och användning. Syftet med den här doktorsavhandlingen är att bidra med ny kunskap till en fördjupad socioteknisk förståelse för delade plattformar. Min analys baseras på ett flerårigt plattformsinitiativ inom den svenska åkeribranschen och följaktligen försöker jag besvara den här forskningsfrågan: "Hur formas utvecklingen av en delad plattform genom det ömsesidiga samspelet mellan konkurrerande aktörers samarbete och plattformens teknologiska arkitektur?" Det huvudsakliga resultatet från mitt forskningsarbete är tre specifika organisationsformer som både möjliggör och begränsar deltagande aktörers innovation under en plattforms utvecklingsprocess.

PREFACE AND ACKNOWLEDGMENTS

Having studied math and software engineering for years, it seemed exotic to become an IS student and engage with qualitative research. Given my engineering background, however, I soon realized it was a lot to learn before being able to start pursuing my dissertation project. The beginning of my research journey was thus an overwhelming experience, but it also made any step in the right direction very rewarding.

Today, understanding the complexity of any IS phenomena behooves the researcher to be equipped with a set of mixed skills. The intertwining of the social and the technical aspects is a given rather than a sophisticated philosophical stance. Indeed, to be able to push knowledge boundaries in our field, one cannot only understand how software and technology architectures are constructed, but also need to fathom the role of social factors and how these two, i.e., technology and humans interact. Throughout my doctoral program, I have thrived to approach my project with such mindset.

Finally, I take this opportunity to express my gratitude to my beloved parents and three siblings for their love, unfailing encouragement, and support.

I hope you enjoy your reading of my work.

Fatemeh Saadatmand

Gothenburg, January 29, 2018

CONTENT

1 INTRODUCTION

Technological platforms are an indispensable part of our contemporary economy in that they mediate the interactions among heterogeneous stakeholders, thereby making disparate systems interoperable (Ceccagnoli, Forman, Huang, & Wu, 2012; Parker, Van Alstyne, & Jiang, 2017; Tan, Pan, Lu, & Huang, 2015). Such frictionless interactions are increasingly important in industries characterized by network effects (Besen & Farrell, 1994, p. 118), i.e., where the value of a product increases based on the availability of complements and/or its adoption by others in the industry. By helping to make products compatible with those products bought by others, platforms play a key role in generating efficiencies and innovation (Boudreau, 2010; De Reuver, Sørensen, & Basole, 2017; Tiwana, 2015). Well-known examples of technological platforms include computer operating systems (Eisenmann, 2008), videocassettes (Cusumano, Mylonadis, & Rosenbloom, 1992), vertical (Markus, Steinfield, Wigand, & Minton, 2006) and e-commerce standards (Zhao, Xia, & Shaw, 2007), as well as social media (Zhu & Furr 2016).

However, technological platforms are not merely digital artifacts; instead they are an emergent organizational form (Gawer, 2014) characterized by (1) a network of actors that innovate in the generation of value and compete for its appropriation (Eisenmann, Parker, & Van Alstyne, 2011; Tiwana, 2015), and (2) a technological architecture composed of a modular core, standardized interfaces, and complementary extensions (Baldwin & Woodard 2009; Le Masson, Weil, & Hatchuel, 2011; Tiwana, Konsynski, & Bush, 2010). As Thomas, Autio, and Gann (2014) highlight, however, platforms differ in terms of their openness, i.e., the degree to which the development, commercialization, and use of the technology is made available to the public (Boudreau, 2010).

1.1 Research Objective

Prior research, however, suggests there are two theoretical perspectives on digital platforms (Gawer, 2014). The economic point of view sees platforms as double-sided markets and has yielded insights on platform competition (Eisenmann et al., 2011). The engineering perspective views platforms as technological architectures and has focused on platform innovation (Boudreau, 2010). These perspectives are rooted in different intellectual traditions with distinct assumptions and they have therefore focused on various directional forces that platforms respond to. Consequently, they have

not helped to explicate how platform competition and platform innovation interact. These forces cannot be understood in isolation because in reality they interact to shape the evolution of platforms with their ecosystems and/or across ecosystems (Gawer, 2014; Tiwana, 2015; Wareham Fox, & Giner, 2014). That is, platforms often evolve in ways that combine innovation with increased competition that renders paradoxical tensions. There is therefore a need for integrative studies of shared platforms and the governance strategies enacted by platform leaders to nurture their ecosystems (Eisenmann 2008; Gawer 2014; Wareham et al. 2014). Indeed, such studies have to be sensitive to dynamic technological landscapes where emerging technology architecture shifts render consequences for coopetitive dynamics (Afuah 2000; Afuah 2004; Bouncken, Gast, Kraus, & Bogers, 2010).

Shared platforms, i.e., consortia that collaboratively design and manage technological infrastructures and rules that regulate the interactions among industry players, are often fraught with challenges. In particular, participating firms have to be convinced continuously of the platform's value, while their position vis-à-vis competitors and complementors dynamically shifts as its architecture and rules evolve.

Compared to proprietary platforms, which are typically developed, owned, and operated by a single firm (e.g., Apple's IOS), shared platforms (e.g., Apache) are developed and operated by a collective of heterogeneous actors (Eisenmann 2008). While this implies that shared platforms are frequently industry-specific (Markus & Lobbecke 2013), I maintain that a key characteristic is that their development, ownership and/or operation is collective. Indeed, competition between cooperating organizations emerge because of a shared reliance on the same platform resources (Ingram & Yue 2008). My definition of shared platforms therefore qualifies Markus and Loebbecke's (2013).

According to Cargill (2002), we can expect shared platforms to become a pervasive organizational form, as it is consortia composed of industrial players interested in solving a particular problem - rather than traditional standard development organizations (e.g., International Standards Organization) - that are increasingly creating standards for the IT industry. Moreover, Zhao et al. (2011) and Grøtnes (2009) maintain that most technology standards are adopted voluntarily (rather than mandated). This suggests that it is important to generate insight into the emergent organizational forms that are shared platforms. In particular, given that these platforms lack a central governing node, the nature of distributed governance

to incentivize their development is a pertinent issue worthy of further scrutiny (De Reuver et al., 2017).

While there is surprisingly little research on shared platform design and the collaborative relationships involved (Chellappa Sambamurthy, & Saraf, 2010), considerable attention has been paid to the cooperative development of the standards that form a necessary part of a platform's technological infrastructure (Le Masson, 2011).

Prior studies of such voluntary, consensus-based processes have examined questions such as how market power and intellectual property rights impact the resulting standard (e.g., Bekkers, Duyseters, & Verspagen, 2002; Rysman & Simcoe 2008), the importance of the working group's chairperson's technical expertise and personal networks within the standardization consortium (e.g., Fleming & Waguespack, 2007), and the role of cooperative relations outside of the standard development organization in the standard-setting outcome (e.g., Leiponen, 2008). In addition, Zhao et al (2007) offer a three-stage process model of technology standardization where they highlight the trade-offs member firms face as they decide whether to participate in the consortium, actively engage in the development of the standard, and adopt it.

Most of this past research on consortium-based standardization emphasizes social factors and fails to consider the role that platforms' underlying architectures play in the process and its outcomes. This is unfortunate because changes in the platform's core often have significant implications for the relationships among participants engaged in the development of the platform interface (Gawer, 2014). Furthermore, the modularity of the extensions (i.e., peripheral components) that third-party providers develop for a given platform largely shapes the platform's innovation potential and its evolvability (Tiwana, 2015), which has implications for the positions shared platform members take vis-à-vis each other (Eisenmann, 2008; Eisenmann et al., 2011).

1.2 Research Question

In this dissertation, I am particularly interested in how the competition and cooperation among horizontally - and vertically - related platform members, i.e., coopetitive dynamics (Adner & Kapoor, 2010; Afuah, 2004; Bouncken et al., 2015), are affected by shifts in the platform's technological architecture. Applying imbrication theory (Leonardi, 2011), which explains how the social and technological aspects of organizational transformation interlock and become interwoven over time, the objective is to expand the

sociomaterial theorizing (Orlikowski and Scott 2008) of platforms (e.g., Barrett, Oborn, & Orlikowski, 2016) by focusing on shared platforms. Hence, the research question reads: "How do the participants' coopetitive behavior and the platform's technology architecture reciprocally shape the evolution of a shared platform?"

This question acknowledges the emergent nature of shared platforms where neither participants' interests nor technological capabilities are known a priori, but are assumed to evolve more or less dynamically over time (Le Masson et al., 2011). Indeed, this dynamism renders the development and management of this organizational form inherently complex and fraught with uncertainty (De Reuver et al., 2017; Leiponen, 2008; Wareham et al., 2014).

My research explores the evolution of shared platform coopetition in dynamic technological landscapes where competitors cooperate to develop technology standards. Given this focus, I identify and conceptualize the tensions (Lewis, 2000) between platform partners, which I empirically examine through a twelve-year (2002-2013) historical analysis (Mason, McKenney, & Copeland, 1997b) of a shared platform initiative in the Swedish road transport industry. The aim of the shared platform was to develop a way to integrate data from embedded, mobile, and stationary technologies to better support processes including the costing of an order, inter-firm load sharing, and dynamic route optimization.

The integration initiative, called the MSI (Mobile-Stationary Interface) project, involved IT vendors, road haulage firms, truck manufacturers, industry representatives, and action researchers. Its main outcome was a new shared platform for integrating the islands of incompatible proprietary IT systems that proliferated in the industry. In particular, I seek to explicate not only the ways in which coopetitive dynamics unfold in such settings, but also how technological shifts may culminate in intensified competition between actors, especially after a technology standard has emerged and cooperation within the industry has been stabilized. Indeed, academics and practitioners alike benefit from a better understanding of the nature of this tension and its potential consequences for ecosystem governance strategies.

I rely specifically on theories of coopetitive relationships, shared platforms, and technology standards which provides me with an initial lens to explore the impact of technology architecture shifts on coopetitive dynamics in shared platform initiatives that integrate heterogeneous technologies by developing new technology standards. Based on an imbrication analysis (Leonardi, 2011), I identify and theorize three organizational forms as

archetypal of shared platforms and assess their respective implications for platform innovation.

The findings of my study explicate not only the ways in which coopetitive dynamics unfold, but also how governance to reduce resource heterogeneity may culminate in intensified competition between cooperating actors after a technology standard has emerged. Based on these findings, I contribute to the platform literature by discussing the nature of the coopetitive dynamics that characterize shared platform initiatives where emerging technology architectural shifts challenge their governance strategies. In addition to these theoretical insights, my dissertation offers implications for platform leaders who seek to nurture innovation in their ecosystems.

My dissertation progresses as follows. I commence with an introduction on the role and definitions of platforms. Next, I present the literature on shared platforms in chapter 3. I continue with a literature review of extant platform research in chapters 4 and 5, focusing on the two dominant perspectives (the economic and the technical) and their respective implications for managing this emergent organizational form. In chapter 6, I offer a comprehensive literature review on sociomateriality and highlight the important debates about this discourse in IS. Against this background, I outline the imbrication framework as my theoretical lens, which is followed by a presentation of the empirical setting in chapter 8. I initiate chapter 9 by giving a summary of my research journey to follow the tradition of dissertation-writing in Sweden and continue by presenting methods for data collection and analysis. Then I report on my empirical analysis summarizing the insights this analysis has yielded. I conclude the dissertation by articulating the key contributions as well as their implications for research and practice.

2 PLATFORMS

Platforms appear to be of central importance in different industries especially in the technology sector. Facebook, YouTube, Uber, Etsy, Instagram, and Visa are examples of platforms shaping users' daily lives. Many of these platforms have generated significant profits which has triggered an increasing interest in platform-powered businesses. Especially because these platforms have unlocked such economic value through unexpected resources, e.g., Airbnb has the highest growth in the hotel industry without owning a single hotel room (Reillier and Reillier, 2017).

Platform-powered companies not only have made high profits but have become highly recognizable brands. Interestingly, many of them were established less than 20 years ago making them much younger than their traditional rivals. Among the top ten most valuable brands in the world, platform-powered companies top the list (Figure 1).
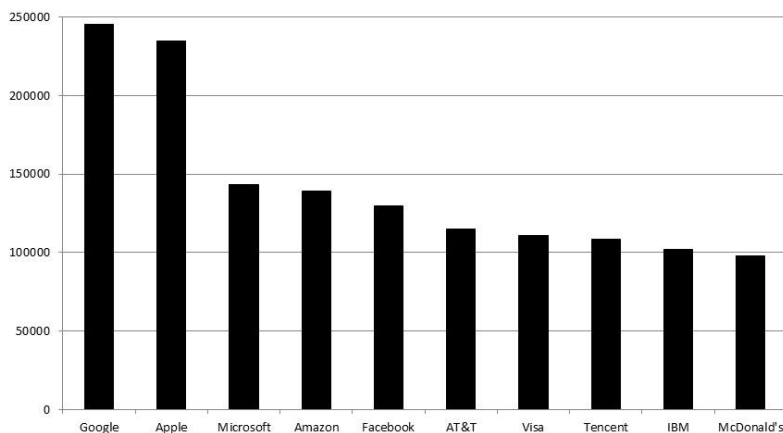

Figure 1 The top 10 most valuable brands in the world (US$ millions)

Source: Millward Brown top 100 brands report 2018

The emergence of these business logics has disrupted the competitive landscape. It has lowered the entry barrier for niche actors and has highlighted the importance of many untapped resources. These changes have

introduced new actors and higher complexities to the markets. For actors, whether established or newcomer, cooperation has become inevitable in order to be able to tackle the complexity of the market.

The introduction of new technologies has made the interconnection between different digital infrastructures possible. But to utilize the technology to build such infrastructure, stakeholders need to cooperate to establish standards, interfaces, and shared platforms. Such collaboration behooves industry actors to develop strategies to share information and expertise on development of such infrastructures but still be able to keep their competitive edge. The establishment of such relationships has introduced new challenges to practitioners. To tackle these challenges, deeper understanding and analysis of such settings is required (Eisenmann, 2008; Gawer, 2014; Wareham et al., 2014; Saadatmand, Lindgren, & Schultze, 2017).

Researchers have been paying considerable attention in studying platforms to shed light on the complexity of platform business model. Management literature alone has seen an increase of more than 180 times in the number of studies on platforms during the time span of 1992 to 2010 (Thomas et al., 2014). This interest has resulted in studies analyzing the phenomena from different angles. In this chapter I present the current conceptualizations of platforms and I clarify the position of this dissertation in the literature. I start by a general review of platforms and continue by zooming into digital platforms specifically.

2.1 Industry Platforms

Platform studies do not use a unified terminology in identifying the "many types" of platforms (McIntyre & Srinivasan, 2017; Porch, Timbrell, & Rosemann, 2015). Instead they are represented with different definitions across literature, e.g., *platform organization, platform technology, product platform, processs platform,* etc. (Thomas et al. 2014; Rochet & Tirole 2003; Eisenmann, Parker, & Van Alstyne, 2006; Gawer & Cusumano, 2002; Armstrong, 2006; Evans, 2003).

A historical view on platform literature shows that the definition of the platform has started to acknowledge the architectural aspects and it also has "diversified and opened up to conceptually exist beyond the boundary of an organization" (Porch et al., 2015, p. 11). This trend can be traced to the fact that platform literature in the beginning of 90s had a broader inclusive definition of a platform; while, recent studies are focusing more on digital/technological platforms. Studies on technology platforms

acknowledge the importance of the role of the architecture of the digital infrastructure shaping the platform.

To solve the issue of lack of a unified view of platforms, Gawer (2009; 2014) presents an integrated and general theory of platforms. To do so, she categorizes platforms, based on the setting they are used for, into three main types: 1) Internal, 2) Supply-chain, and 3) Industry platforms.

Internal platforms are platforms developed by a single firm for the internal use (Gawer, 2009; 2014). The main purpose of an internal platform can be boiled down to turning the structure of the firm's products to a modularized design; hence, enabling the re-use of components across products. Different industries started to witness considerable profit by using internal platforms across products starting in 90s, e.g., the automotive industry (Cusumano & Nobeoka 1998; Bremmer 1999, 2000). The expected benefits of internal platforms are "fixed-cost saving, gaining efficiency in product development through the re-use of common parts, and … gaining flexibility in product design" (Gawer 2009, p. 49).

Unlike Internal platform, a Supply-chain platform targets a group of firms along a supply chain. Every subsystem of a Supply-chain platform is developed by a different firm and the final result "forms a common structure" for the supply chain partners (Gawer, 2009, p. 52). An example of supply-chain platform is Porsche and Volkswagen sharing a common platform for Porsche's Cayenne and Volkswagen's Touareg. The objectives and design principles of Internal and Supply-chain platforms are the same (Gawer, 2009; 2014).

Industry platforms can be designed and developed by one or more firms. The pressing issue in developing an industry platform is to leverage innovation by enabling external parties to contribute to the product and/or services offered by the industry platform. This is done through a well-designed technological structure as an interface to allow third parties to build product and services on top of the platform's infrastructure (Ghazawneh & Henfridsson, 2013). The reason is to encourage innovation by collectively leveraging the platform's value (Grover & Kohli, 2012; Ceccagnoli et al., 2012).

In industry platforms, the platform owner needs to choose a proper strategy through applying "the right" designs rules. Therefore, an economic view of platforms alone does not suffice in theorizing and analyzing industry platforms (Gawer, 2014). Industry platform studies cannot ignore the affordances and constraints of the underlying technology shaping the

architectural leverage (Gawer, 2014; Thomas et al., 2014). The importance of external innovation in industry platform highlights the priority of designing a generative digital infrastructure to uplift the heterogeneous complementary offerings (Tilson, Lyytinen, & Sørensen, 2010).

Thomas et al. (2014) present the platform studies in four literature streams (or categories): *organizational, product family, market intermediary, and platform ecosystem.* After reviewing the literature in platform research they realize that a prominent concept studies point at without conceptualizing it is leverage and the architecture; which Thomas and his colleagues bring up as a necessity in each platform. They underscore the role of the architecture in understanding the evolution of platforms. However, leverage and architecture are only studied in the platform ecosystem literature stream (Thomas et al., 2014).

It is however difficult to separate the platform literature in to the four categories mentioned above (i.e., *organizational, product family, market intermediary, and platform ecosystem*) because platforms are multifaceted social, economic, and technical phenomena. Thus researchers need an integrated body of literature to analyze them. Thomas et al. (2014); however, admit the overlaps of the different categories of platform studies. These overlaps are present in definitions of different types of platforms in IS literature as well. Coherent synergistic means of understanding platforms are a necessity in extending current thinking on platform evolution (McIntyre & Srinivasan 2017; Sun, Gregor, & Keating, 2015; Porch et al. 2015; Thomas et al. 2014).

Another categorization of platforms is presented by Gawer and Cusumano (2014) in classifying platforms as internal and external based on the scope in which the platform is developed and used including inside or outside a firm. However industry platforms that promotes complementarity and external innovation are highly growing (Chesborough, 2006), making it difficult to spot a solely internal platform. Instead internal and supply chain platforms are evolving into industry platforms in order to amass external innovation resources (Gawer, 2009). These changes propose their own challenges and governance practices to the platform owners (Eisenmann, 2008). The trajectory of these changes shapes the evolution of a platform (Thomas et al., 2014).

2.2 Digital Platforms

During 90s many digital innovation products and services, e.g., Microsoft were discussed as industry platforms. Researchers and industry analysts prescribed that technology products needed to evolve into platforms (Cusumano, 2010). A product was characterized as largely proprietary while a platform was seen as a "technology or service that is essential for a broader, interdependent ecosystem of businesses" (Gawer & Cusumano, 2008, p. 28). This definition, however broad, encouraged studies and developments of technology platforms (i.e., digital platforms).

Here, I focus on how different scholars see the definition of digital platforms by identifying three dominant streams .These school of thoughts have varied stances on the way they approach the definition of digital platform and the role of the technology and competition on the platform evolution.

The first view, which I refer to as the economic one, focuses on the economic aspects of platforms. The term platform in this stream characterizes digital platforms as double-sided markets (Eisenmann et al., 2011). Here a digital platform is understood as a mediator between different actors whose only transaction conduit is the platform. Taking into account its socio-technical structure is key to comprehensively understand the ways in which it evolves over time (Gawer, 2014). Viewed from an economic perspective, digital platforms represent one of the three elemental business models for generating value (Stabell & Fjeldstad, 1998).

Frequently referred to as platform markets (Eisenmann et al., 2011), these organizations - at a minimum - bring together buyers and sellers in a two-sided network (Eisenmann, 2008). Increasingly, however, platforms represent multi-sided markets, adding additional parties who derive value from the network effects generated by these business models. Positive cross-side network effects (i.e., the larger the number of buyers, the more attractive the platform is to sellers) and negative same-side network effects (i.e., the less competition there is among sellers, the more likely sellers are to join the platform) are seen as key to the platform's value (Parker & Van Alstyne, 2005) in the economic perspective.

In addition to balancing these two sets of network effects, other economic concerns that are addressed in the platform literature include switching costs, determining which side of the market pays for the platform's services (i.e., money versus subsidy side), growing fast especially when winner-take-all dynamics are in effect, and enveloping platforms with overlapping user bases

(Eisenmann, 2008; Eisenmann et al., 2011; Zhu & Furr, 2016). A key objective of managing platforms is to develop and maintain distributed innovation to support ongoing value creation or generativity (Zittrain, 2006).

The second view describes platforms as a technological infrastructure that allows the disparate systems of two or more organizations to communicate more or less seamlessly with each other (Langlois, 2002). This is the nomenclature adopted by both Tiwana et al. (2010) and Wareham et al. (2014), who refer to the combination of the (technology) platform and the actors who complete it as the "platform ecosystem" (For more details see chapter 4).

Finally the third view urges on marrying the two schools of thoughts above and uses an integrative model to be able to fully analyze the phenomena. Given my focus in this dissertation in exploring the intertwining between the technological and the social in the evolution of a shared platform, I follow the third group and rely on Gawer's (2014) view of platforms as emergent organizational forms (also Le Masson et al. 2011) and define them in terms of two defining features: (1) a network of actors that innovate in the generation of value and compete for its appropriation of value (Eisenmann et al., 2011; Tiwana, 2015), and (2) a technological architecture composed of a modular core, standardized interfaces, and complementary extensions (Baldwin & Woodard, 2009; Le Masson et al., 2011; Tiwana et al., 2010). These dimensions capture the architectural and economic perspectives of platforms respectively.

To be able to study platforms from the above mentioned generative point of view, one need to thoroughly understand the two first views namely the economic market and the technological architecture view of platforms. Therefore, I introduce the literature of these two views in chapters 4 and 5. In chapter 4, I delve deeper into the economic view of the platform and I specifically focus on theories on cooperation between competitors shaping a platform and on governance aspects of such group of actors. In chapter 5, I take a closer look at the previous works on technology architecture of platforms and attend to the related theories, i.e., technology standards and modularity.

Before deeper discussions on the mechanisms of the two different classical views of platforms, I need to get more specific on platform definitions. The platform I study in my dissertation is not a classic proprietary platform but it is a shared platform. In chapter 3, I introduce previous literature on shared platforms and glance through the discussions around them. To underscore the

importance of shared platforms in this study, I have given shared platforms a chapter of its own instead of bringing it up as section 2.3 here.

3 SHARED PLATFORMS

During the course of the evolution of a platform, involved firms can play two different roles: provider and/or sponsor (Eisenmann, 2008). Platform sponsors are the parties who deal with modifying the platform's technology and determine who can take part in the platform network. Being in direct contact with the users, Platform providers are the forefront of the platform from the user's perspective. These roles can be taken by different actors but "… sometimes, a single company plays both roles" (Eisenmann, 2008, p. 33) which are called Proprietary platforms, e.g., Apple Macintosh.

In contrast to proprietary platforms, in shared platforms "multiple firms collaborate in developing the platform's technology and then compete with each other in providing differentiated but compatible versions of the platform" (Eisenmann, 2008, p. 33). With a Joint Venture platform, a single firm provides a platform that has been developed by multiple firms, e.g., CareerBuilder. In a Licensing platform, the platform's technology is developed by a single firm and then licensed to several other firms to serve as the providers. The main difference between these different types in the typology Eisenmann (2008) provides is ownership of the produced value; if a single firm take all the added value as in the Proprietary type or "share the spoils" as in the Shared kind (p. 35).

In the IS literature, platforms that have multiple firms involved in their evolution in different forms are presented as business community platforms or shared digital platforms (Markus & Bui, 2012; Markus & Loebbecke, 2013). Business community platforms are designed to facilitate business-to-business interactions. These platforms are designed and developed to facilitate data and process interoperability between different organizations in a particular industry community, e.g., stock exchange platforms (Markus & Bui, 2012; Markus & Loebbecke, 2013). Business community platforms have also been formulated and presented as Interorganizational coordination hubs (ICH) (Markus & Bui, 2012).

Shared digital platforms, however, are more general than business community platforms. These platforms streamline the processes and data exchange within or between organizations and are developed to be used by multiple firms simultaneously, e.g., Amazon's cloud based hosting services (Markus & Loebbecke, 2013; Loebbecke, Thomas, & Ullrich, 2012). These

platforms standardize and commoditize digital business processes (Markus & Leobbecke 2013). Here the word "shared" is used to underline the *multiple simultaneous use* of the platform other than the multiple development or ownership of it. The very broad scope of the definition of shared digital platform turns this definition into an umbrella term. Eisenman (2008)'s definition of shared platforms also falls under the shared digital platform category presented by Markus and Leobbecke (2013).

The discussion of proprietary vs. shared aspect of a platform is usually tightly linked to the degree of openness. Openness degree of a platform is determined by the restrictions on participation in development, commercialization and use of a platform (Boudreau, 2010; Eisenmann et al., 2009). These restrictions are determined by the architectural design of the platform (Boudreau, 2010; Thomas et al., 2014). Compared to proprietary platforms, where the core is typically developed, owned and operated by a single firm (e.g., Apple's IOS), shared platforms (e.g., Linux operating system, Apache servers) rely on a core that is developed and operated by a collective (Eisenmann 2008). With shared control over the platform core, contributors are less likely to be turned off by the risk of proprietary platform owners enacting usury practices, e.g., raising prices or restricting access to the core.

Openness in proprietary platform refers to the degree third party actors are able and allowed to contribute to the platforms as complementor developers (Eisenmann et al., 2009; Boudreau, 2010). It also refers to the degree certain complements are allowed to be part of the core structure of the platform (Eisenmann et al., 2009). This opening process and the possible actions for the platform sponsors are described as vertical strategy by Eisenmann and his colleagues (2009) elaborating strategic moves to regulate complementor developments and envelopment (i.e., absorbing third party components) (Eisenmann et al., 2011).

In shared platforms, however, the openness is defined as the level of allowing additional rivals in the development, commercialization and use of the core structure of the platform (Eisenmann et al., 2009). Here the strategies of opening are illustrated as horizontal strategy which is focused on deciding to either increasing/decreasing the degree of the interoperability with the rival platforms or inviting more/less rivals as the sponsors of the platform. To do so, other parties are invited to develop the core of the platform collectively (Eisenmann et al., 2009; Gover & Kohli, 2012). This rather radical choice is particularly attractive if the platform sponsor faces an increased pressure from supply/ demand side and/or the rival platforms for open standards to

avoid lock-in (West, 2003). The need for open standards has been the primary reason for the emergence of many open-source platforms (Eisenmann et al., 2009). The degree of openness although is subject to change over time as the platform matures (Boudreau, 2010), this can often result in a blend of the both worlds leading in hybrid governance models (Eisenmann et al., 2009).

Despite the attraction of shard platforms, Boudreau (2010) found that the strategy of opening a previously proprietary architecture was not effective at increasing the innovation and the generativity of the platform. Instead, making a proprietary platform accessible to more third-party developers increased innovation five-fold (Boudreau, 2010). While this research provides insight into the effectiveness of different openness strategies of established platforms, we gain little insight into the implications of participating in the development of a shared architecture from the beginning.

In my dissertation, I rely on Eisenmann (2008)'s definition of a shared platform. He defines such platforms as consortium of firms that set standards, share infrastructure costs, and rely on a common platform to communicate with each other (Eisenmann, 2008). These platforms are an increasingly common organizational form as firms seek to develop industry-specific interoperability through standardized interfaces. Cargill (2002) highlights that consortia, composed of industrial players interested in solving a particular problem (rather than traditional standard development organizations such as the ISO) are increasingly creating standards for the IT industry. Furthermore, Yates and Murphy (2014) point out that most industry standards are developed by private standard setting organizations (rather than government regulators or individual firms) and adopted voluntarily (rather than mandated). This highlights the importance of generating insight into the emergent organizational forms of shared platforms.

Even though Le Masson et al. (2011, p. 273) note that "surprisingly little research has been done on [shared] platform design and the collaborative relationships involved", there is nevertheless considerable research on the cooperative development of the standards that form a necessary part of a shared platform's infrastructure. This research on "voluntary consensus standards setting processes" (Yates & Murphy, 2014) examines such questions as how market power and intellectual property rights impact the resulting standard (e.g., Bekkers et al., 2002; Rysman & Simcoe, 2008; Backhouse, Hsu, & Silva, 2006), the importance of the working group's chairperson's technical expertise and personal networks within the standardization consortium (e.g., Fleming & Waguespack, 2007), and the role

of cooperative relations outside of the standard development organization in the standard-setting outcome (e.g., Leiponen, 2008). Also, Zhao et al. (2007) develop a three-stage process model of consortium-based standardization in which they highlight the trade-offs participating firms face as they decide whether to take part in the consortium, actively engage in the development, and adopt the resulting standard. Schilling (2009) looks into different pathways to achieve dominant design, different technology strategies and different control mechanisms in standard making in technology platforms.

However, most of this research on collaborative standardization emphasizes social factors (e.g., knowledge assets and relationships between actors) and fails to consider the role that technology (e.g., architecture) plays in the process and its outcomes. This is problematic because changes in the technology's infrastructure have implications for the relationships among participants engaged in the development of the platform standard (Gawer, 2014).

Given the nature of shared platform, in the next chapter (i.e., Platform as Markets) I focus specifically on an economic view of platforms that are developed by a consortium of competitors. In chapter 5, I go through the architecture of platforms in a broader perspective under by going through modularity under section 5.2. I also give technology standards a special focus in section 5.1.

4 PLATFORMS AS MARKETS

Zhao et al. (2011) highlight that a key economic issue with platforms revolves around participants' incentives: why do consortium members spend time and money participating in the development of a technological core and standard interface, when these are likely to be made freely available to non-participants? While this research identifies key reasons behind why firms join a standard-setting industry consortium (e.g., perceived benefit of the standard, perceived benefit of collective action), it falls short of identifying how these perceived benefits change over time as the participants' relative positions in the consortium and the emerging industry shift.

Analyzing the changes of competition and cooperation between platform's industry actors is a viable way to understand the underlying causes of these changes. I introduce coopetition, its different modes in this chapter, and coopetition governance strategies in this chapter.

4.1 Coopetition Modes

Coopetition is a promising way of operationalizing the dynamics of a firm's position within the platform-developing consortium and the industry. Coopetition captures situations where cooperation and competition among industry players occur simultaneously (Bengtsson, Eriksson, & Wincent, 2010; Bengtsson & Kock, 2014). It breaks with the classical assumption that relationships between firms are fairly static and either cooperative or competitive in nature (Walley, 2007). Viewing cooperation and competition as a duality rather than a dualism has proved a powerful strategy for theorizing collective action in intra-firm (Tsai, 2002) and inter-firm networks (Bengtsson & Kock, 2000).

The concept of coopetition is an oxymoron of cooperation and competition that refers to situations where competitors cooperate to gain competitive advantage (Bengtsson et al., 2010; Bengtsson & Kock, 2014; Chen, 2008; Nalebuff, Brandenburger, & Maulana, 1996). It breaks therefore with the traditional assumption that relationships between firms are either cooperative or competitive in nature (Walley, 2007). Viewing cooperation and competition as a duality rather than a dualism has proven to be a powerful strategy for theorizing collective action in firm networks (Tsai, 2002) as well as inter-firm networks (Bengtsson & Kock, 2000). Therefore, coopetition is seen as a promising way of operationalizing the dynamics of a firm's position within the platform-developing consortium and the industry (Gawer, 2014).

The studies on coopetition has increased since Raymond Noorda employed the term in 1992 to describe Novell's business strategy (Bengtsson & Kock, 2014) which was later used in strategy literature by Nalebuff and Brandenberger (1997). However, despite the popularity of coopetition especially in technology focused industry sectors (Gnyawali & Park 2009; Chin, Chan, & Lam, 2008) the literature on cooperation has not become entangled into the literature on competition still. This means that the intricate interplay between cooperation and competition is still under-researched (Hoffman, Lavie, Reuer, & Shipilov, 2014; Luo, Rindfleisch, A., & Tse, 2007; Bengtsson, Kock, Lundgren-Henriksson, & Näsholm, 2016). Indeed, studies of coopetition in shared platforms can carefully explore the intricate interplay between these two modes and theorize the different patterns of their coevolution. Of particular interest is to identify what are the antecedents, mechanisms, and consequences that drive their interplay and how they shape platform processes (Gawer, 2014).

Coopetition can emerge in different forms based on the intensity of cooperation and the intensity of competition in the relationship between firms. Bengtsson et al. (2010) reinforces that coopetition needs to be seen as a phenomenon there the relationship between competition and cooperation is not linear but it needs to be seen on a continuum. Consequently, "the implication is that co-opetition is described as ranging from strong competition to strong cooperation" (Bengtsson et al. 2010, p. 199). These changes of coopetitive behaviors are called *coopetition dynamics* by Bengtsson et al. (2010).
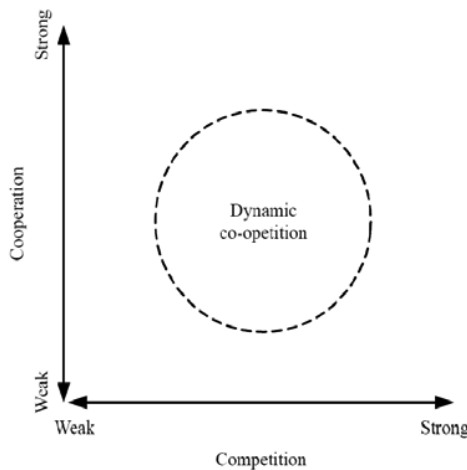

Figure 2 Coopetitive inter-firm relationships (Bengtsson et al. 2010)

Outlining a conceptual framework for defining and studying coopetition, Bengtsson et al. (2010) maintain that coopetitive relations imply that two firms are cooperating on one activity and competing on another. For example, in the early 2000's, mobile phone manufacturers Erikson, Nokia, Sony and Samsung cooperated in an effort to develop the Symbian operating system that Internet-enabled mobile phones. Despite this collaboration, the handset manufacturers nevertheless remained rivals in the products they offered customers. Given that coopetition implies two activities (e.g., R&D and sales), Bengtsson et al. (2010) visualize this inter-firm relationship in a two dimensional space (see figure 2) that is characterized by two continua: competition and cooperation.

Bengtsson et al. (2010) highlight that for coopetition to be productive; the forces of competition and cooperation need to be balanced. Too little competition is associated with inertia and even collusion as firms lack the incentive to innovate while too much competition generates a level of hostility and confrontation that makes any kind of cooperation between rivals virtually impossible. Similarly, too little cooperation (i.e., distant, arm's length contracting) fails to generate the trust needed for firms to share information and knowledge, while too much collaboration undermines knowledge production and innovation due to group-thinking (i.e., over embeddedness). Thus, for coopetition to avoid the potentially negative consequences of competition and collaboration, the two forces need to remain in tension, albeit in a way that the imbalance between them is minimal. It is this productive conflict between the forces of cooperation and competition that Bengtsson et al. (2010) label dynamic coopetition (indicated by the circle in figure 2).

Simultaneity of a cooperation and competition is the cornerstone of coopetition and can emerge as vertical or horizontal coopetition (Dowling et al., 1996); However, to get the maximum innovation performance out of an interfirm relationship a firm ought to form both vertical and horizontal linkages (Teece, 1998). Different studies have examined the effects of the interaction of these key pillars of coopetition. These studies have mainly focused on examining the intensity of cooperation and competition in the success of interfirm relationships. Success in this context is defined as generating technological innovations as the outcome of coopetitive relationship (e.g., Park et al., 2014) with a special focus on value creation and value appropriation theories (e.g., Lavi, 2007) and common stakes (e.g., Akpinar & Vincze, 2016). Some researchers conclude that the most fruitful

coopetitive relationship emerge when competition and cooperation are simultaneously at a high intensity. Gnyawali et al. (2008) believe that intensive cooperation in coexistence of intense competition result in higher innovation performance. While others believe the simultaneous intensified competition and cooperation result in extreme conflicts and disagreements leading to many tensions (Bengtsson et al., 2010).

Coopetition can change dramatically overtime; these changes are referred to as coopetitive dynamics. Although these dynamics determine win or lose in such relationships, they are not fully analyzed in the literature. The acute need for explaining coopetitive dynamics is widely recognized. Existing studies on coopetition rely on the game theory, the resource-based view, and the network approach (Bengtsson & Kock, 2014). These approaches are used to analyze the levels of competition and cooperation between coopetitors but fall short in analyzing the changes. Theoretical informed frameworks are needed to explain these dynamics to contribute to understanding of the field.

My conceptualization of coopetitive relationships and subsequent empirical analysis is consistent with the conceptualization of coopetition and the frameworks developed in the literature (Park et al., 2014; Bengtsson et al., 2010; Lado, Boyd, & Hanlon, 1997; Bengtsson & Kock, 2000). This conceptualization is shown in figure 3. Strong cooperation in an interfirm relationship with weak competition results in *cooperation dominant* relationship. The high trust that underlies this coopetitive mode creates strong and stable bonds, which makes innovation – with its disruptive implications – more challenging.

Similarly, a strong competition in combination with weak cooperation results into a *competition dominant* relationship. Since the rivalry among firms is high and competing firms are primarily motivated by distinguishing themselves from others, actors are inclined to protect rather than share their ideas. Even though innovation is spurred in this coopetitive mode, it is unlikely that a meaningful synergy of innovative ideas is produced, thus limiting its impact to make the industry as a whole – and all the players within it – better off (Park et al., 2014).

When both cooperation and competition are weak the relationship lacks dynamism (Bengtsson et al., 2010; Bengtsson & Kock, 2000) causing a *static* coopetition (Bengtsson et al., 2010). A static coopetition is too weak to generate enhanced technological progress (Park et al., 2014) and bring about monopolistic rent-seeking behaviors (Lado et al., 1997). When industry actors lack the motivation to upgrade their market position (low competition)

and knowledge exchange with other actors is limited (low cooperation), it is unlikely that innovation will occur (Park et al., 2014).

Focusing on a synergistic view on competition and cooperation, Lado et al. (1997) proposes a fourth behavior type in interfirm interactions called *syncretic* behavior. This coopetition mode entails an aggressive but at the same time cooperative relationship where firms seek extra rents in a relationship with high degree of competition to stimulate knowledge development, market growth, and economic rents but eschew tensions through frequent collaborations. Lado et al. (1997) build their argument partly on Roehl and Truitt analysis of American, Japanese and French ventures concluding that "open, stormy marriages" resulted in more productive relationships (Roehl & Truitt, 1987, p. 87). In the similar vein, Park et al. (2014) suggest that the combination of high competition and high cooperation fosters a balanced interaction that enhances innovation performance. However, this mode creates highly paradoxical dynamics as strong competition inhibits cooperation, and vice versa.

Toggling between the two extremes (high cooperation at one time or on one initiative, and high competition at another time or on a different initiative) is one way of managing the contradictory nature of coopetition. Another approach, as stated earlier, is to seek extra rents in a highly competitive relationship in order to stimulate knowledge development, market growth, and economic rents, and to rely on high cooperation to manage the competitive tensions (Lado et al., 1997). While this coopetitive mode is conducive to the generation of innovation, its performance as a mechanism for materializing ideas that will make the entire industry better off, is uneven.

In light of each coopetitive mode's limitations with regard to innovation, Bengtsson et al. (2010) advance a fifth coopetitive mode, labeled *dynamic* coopetition that emphasizes the combinability of moderate degrees of competition and cooperation respectively. With firms seeking to distinguish themselves from others in some areas and working together with others in order to improve infrastructural aspects of the industry, this mode of coopetition is deemed the most productive with respect to innovation. Bengtsson and her colleagues believe that interfirm relationships characterized by high levels of competition and cooperation are truly difficult to sustain damaging innovation and knowledge exchange processes widely (Bengtsson et al., 2010).

Overall, the dynamic interplay between cooperation and competition remains under-researched (Hoffmann, Lavie, Reuer, & Shipilov, 2014) and the

evolution of shared platforms provides a unique opportunity to explore this phenomenon (Gawer, 2014).

Figure 3 Coopetition mode conceptual model

To be able to evaluate the intensity of cooperation and competition, I follow Bengtsson et al. (2010)'s conceptual model of pillars of cooperation and competition. Competitive relations are defined in terms of symmetry of product, intensity of competition and hostility, while cooperation relations are evaluated in terms of complementarity of product, trust, and tie strength (Bengtsson et al., 2010). The definition of these six coopetition elements is presented in table 1.

In my analysis, I look at the strength of cooperation and competition by scrutinizing the strength of each constituent component mentioned above (Table 2 and table 3). Based on these criteria, cooperation (and competition) scores were deemed strong if all its components score high; it scores weak if at least two of its components score low; and it scores moderate if two of its components score high (For more details refer to Appendix 2). These dyadic scores were then averaged to derive a coopetition score for the entire MSI network in each phase. This allowed me to trace the coopetitive dynamics over the course of the platform's evolution and to explore the reciprocal relationship between the material agency of the architecture and the human agency of the MSI participants.

Table 1 Coopetition key elements

Concept	Definition	References
Hostility	Hostility is characterized by the perceptions a firm holds of another firm; is it a partner, a "good" competitor, or an enemy. Therefore it is very prestigious to win over a competitor when hositility is high.	Bengtsson et al. 2010 Baldwin and Bengtsson, 2004 Easton, 1990
Symmetry	Symmetry occurs when competitors operate in the same product and market segments, while using the same resources .The degree of symmetry or similarity can vary, however, as firms can offer different products to the same market and so forth.	Bengtsson et al. 2010 Chen, 1996
Intensity	Intensity emerges when frequent moves and countermoves occurs between competitors. When intensity is high competitors are affected by moves made by others.	Bengtsson et al. 2010 Ferrier, 2001 Chen et al., 2007 Porac et al., 1995 Easton and Araujo, 1992
Trust	Trust is the necessary element in cooperative relationships to encourage sharing of information, and resources. High degrees of trust, therefore, aid innovation and continuous cooperation.	Bengtsson et al. 2010 Larsson et al., 1999 Uzzi, 1996 Li and Ferreira, 2008
Tie strength	Tie strength shows the interaction patterns between competitors. High tie strength signals a cooperative relationship. Variables such as closeness, frequency of contact, and common projects represents high tie strength.	Bengtsson et al. 2010 Granovetter, 1973 Marsden and Campbell, 1984
Complementarity	Complementarity between partners stems from resource complementarity. A complementary inter-partner resource alignment is present when dissimilar resources are contributed and these resources are fully performing for the achievement of alliance goals.	Bengtsson et al. 2010 Das and Teng, 2003

Table 2 Cooperation strength based on its key elements

Cooperation Strength	Trust	Complementarity	Tie strength
Weak	Low	Low	Low
Moderate	Low	High	High
Moderate	High	Low	High
Moderate	High	High	Low
Strong	High	High	High

Table 3 Competition strength based on its key elements

Competition Strength	Symmetry	Intensity	Hostility
Weak	Low	Low	Low
Moderate	Low	High	High
Moderate	High	Low	High
Moderate	High	High	Low
Strong	High	High	High

4.2 Governance Strategies

If a firm has come to depend on its coopetitor's capabilities, however, obsolescence of their capabilities can also result in lower performance for the firm. That is, collaborative relationships with coopetitors, which are usually a source of competitive advantage, can become a handicap when a technology architecture shift renders coopetitors' capabilities obsolete (Afuah, 2000). This means firms ought to pay attention not only to the impact of the shift on their capabilities, but also to the impact of the shift on their coopetitors (Afuah, 2004).

A central advantage of coopetition is achieving shared technical innovations by using the pool of technological capabilities of partners and swaying the knowledge asymmetries. This is particularly lucrative because competitors are confronted with many same problems to solve because of the same

customer base. On the other hand, their quest in finding the right technological capabilities to solve the same problems makes them perfect technological complementors in a shared platform setting. Thus, the benefit of such shared efforts is vital to innovation processes (Bouncken et al., 2015).

However, the similarity of the market situation and customer groups make coopetitive relationships difficult at best. This is even more relevant in industries highly affected by shifting in technologies. The conditions of such industries turn technological capability into the most important competitive edge. Thus, competitors would be less eager in disclosing their capabilities and bring their knowledge to a shared project to their competitors which results in a complicated dynamism in the coopetitive relationship (Baumard, 2009). This complexity is rarely captured in longitudinal empirical studies. The lack of such studies is very visible in theoretical implications for academics and useful management recipes for practitioners governing such efforts.

Shared platform initiatives that face technology architecture shifts when developing technology standards are excellent milieus for advancing the current understanding of the evolution of coopetitive dynamics and their respective implications for platform governance strategies. The variety of the technologies and stakeholders involved in shared platform initiatives constitutes a complex and rapidly changing ecosystem (Wareham et al., 2014). Such ecosystem needs to encompass heterogeneous groups of technology vendors and user organizations without fragmenting, and platform initiatives that evolve into rival, homogeneous groups are less likely to develop a new technology standard that wins industry acceptance (Markus et al. 2006).

Although platform literature acknowledges coopetition (e.g., Mantena & Saha 2012; Ritala, Golnam, & Wegmann, 2014), coopetitive dynamics in shared platform literature have not yet been exploited. This is a gap addressed in this study. I believe in the potentials of the coopetition and shared platform literature to complement each other; this is because shared platforms are mainly established between partners who simultaneously compete and cooperate with each other (Eisenmann, 2008). They cooperate in contributing to the shared platform development and maintenance but compete in attracting more customers and taking a bigger share of the market (Bengtsson & Kock 2000). This has similarities to coopetition's main assumption, that is; firms cooperate to create value but compete in obtaining the bigger share of the pie (Nalebuff et al., 1996).

Despite a long history of standardization research on development barriers, switching costs, diffusion patterns, and network effects (Backhouse et al. 2006; Chen & Forman, 2006; Weitzel, Beimborn, & König, 2006), many shared platform initiatives fail. Lack of adequate governance that leads to coopetitive relationships becoming competition-dominant is to blame for such failures (Garud, Jain, & Kumaraswamy, 2002; Saadatmand & Lindgren 2016). Recent research has therefore called for studies of coopetition evolution (Bouncken et al., 2015) and platform governance (Eisenmann, 2008; Eisenmann, 2011; Tiwana, 2015; Wareham et al., 2014). For example, Wareham et al. (2014) point out that a better understanding of changing maturity levels of governance strategies would help explicate the ways in which coopetition in shared platform evolves. Here Gawer's (2014) integrative framework offers a theoretical foundation that allows me to explore how decisions about platform scope and degree of platform openness interact and why they affect platform innovation and competition. Indeed, such exploration may reveal what are the drivers and consequences of changes in the degree of openness of platforms as they evolve over time.

Coopetition is considered a strategic choice to leverage interoperability and developing shared platforms. In the technologically-intense ecosystems data plays an excruciating role in leveraging competitive advantage for the firms and helping them make data-informed decisions. However, firms today are finding themselves more and more in overlapping ecosystems. Thus, to make their data more meaningful they cannot only rely on their own data but they need to obtain or collect data from their ecosystem and the ecosystems they find their firms at the intersection of. To do so, firms today need to engage and invest in collaborative efforts that focus on developing standards and platforms that promote interoperability. They need to engage in developing data structures and communication standards with other firms in different market position and ecosystems to be able to exchange data. The idea is sound: Individual firms should not engage in wheel-reinvention processes; they need to be able to adapt their own system modules to be able to communicate with their partners.

However adopting such standards and, minimally or largely, altering the business processes to compromise for the standard is easier said than done. Heterogeneity of actors that need to design, develop and/or adopt such standards makes the process complicated. The dynamism of the competition landscape constantly affects the incentives of collaborations and vice versa. By the same token, technology asymmetry (Mantena & Saha, 2012) and power imbalance in these stormy partnerships (Markus & Loebbecke, 2013)

do not reduce the complexity of governing and adopting these intermediary systems.

This complexity calls for a well thought out managing strategy to dampen the turbulence of coopetive relationship and turn it into a fruitful collaboration, i.e., dynamic coopetive relationship (Bengtsson et al., 2010). One should also have in mind that the paradoxical nature of coopetition makes it prone to tensions in different levels: inter- organizational, intra-organizational and inter-individual (Fernandez, Le Roy, & Gnyawali, 2014).

To date, the research on managing coopetition is limited to the dyadic relationships between two firms. In this context, three management strategies are identified (Fernandez et al., 2014): separating the collaborative and cooperative activities by making different parts of the organization responsible for each relationship type (e.g., cooperation in upstream activities such as R&D and competition in downstream activities such as sales and marketing); outsourcing the management of coopetive relationships to a third party (e.g., a customer or trade union); and learning to integrate the collaborative and competitive logics of a coopetive dyadic relationship by learning paradoxical management principles (e.g., making long-term commitments and building trust).

How these strategies of separation and integration might be applied within a dynamic network of platform participants is not clear however. The separation crowd mainly looks at the competition as the dominant mode of relationship in activities closer to the customer and cooperation as the strategy for activities far from customers (e.g., Gnyawali & Park, 2011); while, the integration advocates do urge on simultaneous coexistence of both modes in all activities. The latter mode is been called hybrid mode by Oshri and Weeber (2006).

Dealing with firms in multiple roles, if not managed, may actually increase uncertainty, reduce stability, and create real costs to the firms involved (Dowling et al., 1996). Coopetive relationships occur when technological development is accelerated in collective collaborations with competitors (Von Hippel, 1987). Dowling et al. (1996) suggest that coopetive relationship are common in industry sectors that technological change is rapid; although, the presence of industry standards are of huge help for coopetition to survive technological waves (Sahaym, Steensma, & Schilling, 2007). It is not clear how technology capability asymmetry affect these relationships however.

Even though the definition of coopetition offered by Bengtsson et al. (2010) focuses on the relationships between two firms, industry dynamics nevertheless play an important role in creating inter-firm coopetition (Nalebuff et al., 1996). Specifically, how the value net of customers, suppliers, complementors and competitors align to add value to a focal firm shapes the landscape that affords and constrains the firm's ability to form coopetitive relationships with other actors in the network.

It is important to note that industry-specific, shared platform initiatives create the quintessential conditions for coopetitive dynamics as horizontally-related competitors cooperate with each other, and new coopetitive dynamics between vertically-related complementors are likely to emerge. Shared platform development projects, especially longitudinal ones (Bengtsson et al., 2010), are thus particularly conducive for learning more about coopetitive dynamics and ways of managing them so that the tensions between cooperation and competition among platform members remain sufficiently imbalanced to be productive. A key risk of shared platforms is that they encompass heterogeneous groups of technology vendors and user organizations whose divergent interests threaten to fragment the ecosystem, thus devolving it into rival, homogeneous groups that are less likely to develop a new, integrative technology (Wareham et al., 2014).

There are two schools of thoughts regarding coopetition strategy: One focuses on stakeholders and the other on the activities. In the actor school of thought coopetition is seen as a game that consists of different kinds of players. To gain value, every player constantly tries to balance the the costs by constantly adjusting the level of cooperation and competition. In this viewpoint, researchers try to understand the dynamic of coopetition by analyzing the network structure, the position of each actor in the network, and its effect on value proposition for the specific actor types. Here the coopetition is a constant repositioning of the actors there they decide how to change the degree of competition with stakeholders they cooperate with to gain extra rents. This stream of research in coopetition focuses on the network configuration of the value chain from different angles (Bengtsson & Raza-Ullah, 2016): these studies mostly focus on the network from the focal firm's point of view (e.g., Ritala et al., 2014).

The activity school of thought shifts the focus from the network configurations to the dynamics of the relationships between the actors. Studies in this category magnify the dyadic relationships of coopetitors in quest for analyzing and understanding the paradoxical interaction between firms that compete and cooperate at the same time (Bengtsson & Raza-Ullah,

2016). The paradox in such interactions results in tension-filled relationships; especially, in cases that the only value proposition solution is "sleeping with the enemy". A fine grained analysis is needed to understand the micro foundations of coopetition between two firms to be able to fathom the underlying causes and mechanisms of the tensions. To fill up this lacuna studying the evolution of coopetition over a longitudinal project is frequently encouraged (Bengtsson & Raza-Ullah, 2016; Hoffman et al., 2014).

The two schools of thoughts give different understanding of different levels of the coopetition; however, literature on coopetition lacks an integrative model to analyze coopetition on different levels. Such holistic view on coopetition is discerned as an effective analysis to prevent coopetition failures (Bengtsson & Raza-Ullah, 2016).

5 PLATFORMS AS ARCHITECTURES

Digital infrastructures of platforms are large, heterogeneous, and complex information systems (Hanseth & Lyytinen 2010; Hanseth & Monteiro 1997; Henfridsson & Bygstad 2013; Tilson et al., 2010). Recognizing the sociomaterial nature of infrastructures (Ciborra et al., 2000; , 1995), Star and Ruhleder (1996) highlight the interdependence between technology components and social actors and how they mutually shape and reshape the infrastructure. The heterogeneity of a digital infrastructure can thus be traced to how different actors appreciate and interpret complex technology components based on their perspectives and interests (Gal, Lyytinen, & Yoo, 2008; Yoo, Lyytinen, & Yang, 2005). Digital infrastructures usually have no fixed boundaries and they evolve continuously and unexpectedly (Ciborra et al., 2000).

The existing infrastructure, or the installed base, conditions how they evolve (Star & Ruhleder, 1996) and other factors than technical superiority shape the process through complex dependencies between technical and social elements (Hanseth & Lyytinen, 2010; Hanseth & Monteiro, 1997). Accordingly, Lyytinen and Yoo (2002, p. 379) suggest digital infrastructures are "technically heterogeneous, geographically dispersed, and institutionally complex without any central coordination mechanism." This systemic characteristic (Sahay, Monteiro, & Annestad, 2009) implies that a change in any component generates non-linear translations and challenging negotiations (Pipek & Wulf, 2009; Yoo et al., 2005).

I precede the discussions on the architecture of the digital infrastructure of platforms by focusing on technology standards given the importance of standards in shared platforms. Next, I go through the literature that focuses on the modularity of the platform architecture design. Given the central role of interfaces in modular designs the discussion of standards comes up under modular section again. I conclude this chapter by point at connections between the architecture design and the strategy decisions in platform development.

5.1 Technology Standards

Standardization efforts seek to achieve conformity across players within an industry platform by reducing complexity, improving coordination, and ensuring interoperability and stability (Braa, Hanseth, Heywood, Mohammed, & Shaw, 2007; Hanseth & Lyytinen, 2010; Hanseth, Jacucci,

Grisot, & Aanestad, 2006; Hepsø, Monteiro, & Rolland, 2009). Formal and dedicated standard development organizations (SDO) are institutional arenas for such consensus building and overruling of heterogeneous interests (de Vries, 1999). However, SDOs are not well suited for standardizing technological systems in complex and rapidly changing environments (Weiss & Cargill, 1992). In these cases, informal and ad-hoc industry consortia may facilitate swift exploitation of commercial possibilities through coordinated standardization efforts (e.g., Markus et al., 2006). In any case, standards are "limited set[s] of solutions to actual or potential matching problems directed at benefits for the party or parties involved, balancing their needs and intending and expecting that these solutions will be repeatedly or continuously used during a certain period by a substantial number of the parties for whom they are meant" (de Vries, 1999, p. 13). As such, they apply to a variety of entities, including products, processes, services, materials, equipment, systems, interfaces, protocols, functions, methods, and activities.

Horizontal IT standards cover specifications of hardware, software, and data communication to enable technological interoperability (Chen & Forman , 2006; Garud et al., 2002). They define how different components should work together to increase system utility (Garud & Kumaraswamy, 1993) and to provide incentive for developing complementary assets (Teece, 1986). They also allow for substitution of components as more advanced solutions become available, thus reducing the risk of system obsolescence. In contrast, vertical IT standards provide semantic representations of business processes, descriptions of non-functional requirements, definitions of data structures, specifications of document formats, and desired functionality of information systems for particular industries (Malhotra, Gosain, & El Sawy, 2007; Markus et al. 2006; Steinfield, Markus, & Wigand, 2011; Wigand, Markus, & Steinfield, 2005a; Wigand, Steinfield, & Markus, 2005b).

Bala and Venkatesh (2007, p. 341) note that these conceptual standards "not only specify and define the structure and format of business messages through a common language but also orchestrate the message exchange choreography, i.e., the sequence of steps required to execute an atomic business process among trading partners". As such, they describe procedures and practices that should be followed to achieve a desired outcome. Extant studies of vertical IT standardization address collective action dilemmas (Chang & Jarvenpaa, 2005; Markus et al., 2006; Reimers & Li, 2005; Zhao et al., 2005), standards adoption in organizations (Damsgaard & Truex, 2000; Bala & Venkatesh, 2007; Hanseth et al., 2006), extended enterprise arrangements (Beck & Weitzel, 2005/2006; Reimers & Li 2005; Zhao et al., 2005), standards adoption in organizations (Damsgaard & Truex, 2000; Bala

& Venkatesh, 2007; Hanseth et al., 2006), extended enterprise arrangements (Beck & Weitzel, 2005; Malhotra et al., 2007), and industry effects (Christiaanse & Rodon, 2005; Gogan, 2005; Steinfield et al., 2005; Wareham, Rai, & Pickering, 2005; Wigand et al., 2005b). Most of these studies focus on regulatory standards that help industry players seamlessly integrate existing business processes mediated by IT.

So far, we know little about vertical standards in domains where generic behaviors do not exist. Instead of streamlining existing business processes, these anticipatory vertical IT standards define new procedures and practices for information and infrastructure sharing (Lyytinen & Newman, 2008) to "guide the emergence of new technologies and consequently indicate far ahead in advance of the market's ability to signal the features of products that users will demand" (David, 1995, p. 29). Recent IS research suggests these standards play an increasingly important role in relation to embedded and mobile technologies (Andersson, Lindgren, & Henfridsson, 2008; Henfridsson & Lindgren 2005; Lindgren, Andersson, & Henfridsson, 2008). However, anticipatory vertical IT standardization involves novel principles for institutionalized industry practices and new solutions that convey possible future worlds (Andersson et al., 2008; Lyytinen & Newman, 2008). Such innovation efforts are highly uncertain because they require significant changes in individual and collective socio-technical capabilities. They therefore typically unfold as non-linear, emergent, and path-dependent processes of design, negotiation, and sense-making on multiple levels (Lyytinen & Newman, 2008).

5.2 Modular Systems

Baldwin and Woodard (2009) define platform structure as a modular technological architecture that consists of stable core components complemented by variable periphery components. Interfaces and/or protocols facilitate communication between these components within a standardized architecture (Langlois, 2002; Langlois & Robertson, 1992). Indeed, their mediating role is even more important when a digital platform is open and generativity is of particular concern (Boudreu, 2010), because they serve as architectural control points between modules and layers (Baldwin, 2008; Baldwin & Woodard, 2009; Wareham et al., 2014). As such, by helping platform owners to control granting access to complementors, these interfaces/protocols provide a key governance mechanism to reconcile paradoxical tensions in shared platform initiatives (Wareham et al., 2014). Such governance is necessary to involve actors who take different sides of a

digital platform, thus contributing to its overall performance and positive progression (Hagiu & Wright, 2015). While there have been studies of this type of actor involvement, however, most of them concern rather homogenous platform situations. This is unfortunate because shared platform initiatives in many industries often rely on heterogeneous milieus characterized by actors who simultaneously engage in cooperation and competition (Wareham et al., 2014).

Tiwana et al. (2010) highlight also that a platform's technological architecture comprises three components: (1) a core, (2) interfaces, and (3) (third-party) modules that expand the platform's functionality. This definition draws on Baldwin and Clark's (1997) general principles of modular systems design, which advocate that systems have modules whose design parameters are hidden (i.e., encapsulated core modules) and visible design rules that facilitate inter-module interaction (i.e., specified interfaces). According to Baldwin and Woodard (2009), the core is the hidden layer of the platform architecture, while the interface, which is typically seen as the standard in an integration initiative, is overt and easily discernable. The initiatives reported as standardization studies might thus be more accurately described as platform development efforts.

The architectural core, which serves as "one component of or subsystem of an evolving technological system when it is strongly functionally interdependent with most of the other components of the system" (Gawer and Henderson 2007, p. 4) acts as a mediating device by transferring messages between disparate platform users (e.g., buyers and sellers) thereby coordinating their efforts (Bresnahan & Greenstein, 1999). According to Gawer and Cusumano (2008, p. 29), the core "should perform at least one essential function … or solve an essential problem within an industry". At the very minimum, the architectural core needs to offer brokering services such as user registration, message addressing and message validation in order to coordinate traffic between platform participants who would not otherwise interact.

The core is made accessible to third-party modules through an interface, which comes to serve as a standard of interoperability for platform players (Boudreau, 2010). The specifications of these standardized interfaces govern component interaction (Baldwin & Woodard, 2009) by acting as a "treaty between two or more sub-elements" (Baldwin & Clark, 2000, p. 73).

Table 4 Criteria for conformability of the platform interface

Criterion	Definition
Clearly Specified	Functions and parameters have self-explanatory, consistent names.
Unambiguous	Related concepts are named unambiguously. It should be easy to associate the names with the right concepts without looking them up in the documentation.
Well-documented	A well-documented interface must have: 1) datatypes specs, 2) function specs, and 3) an introduction document that binds the whole into a logical entity.
Stable	The object model is adaptable to future changes including removing data types, renaming them, or removing properties.
Standardized	An interface that allow different technologies to work together, regardless of language or platform.

Implemented through a variety of technologies such as XML and APIs, interfaces force module developers to format their input and output parameters in ways that other modules can send message to and receive messages from them. As boundary resources that allow the platform provider to maintain control over the services of the core while encouraging the development of extensions, interfaces represent powerful mechanisms for platform governance (Ghazawneh & Henfridsson, 2013). The architecture's interfaces and the degree of core-extension coupling thus represent sources of strategic tension between platform providers and extension developers (Tiwana, 2015) as they set the communication rules.

An interface glues the different components of a quasi-decomposable system design provided different component developers are required to conform to it (Sanchez & Mahony, 1996). This conformability of interface is achieved if it is clearly specified, unambiguous, stable, well documented, and standardized

(Tiwana, 2015; Sanchez & Mahony, 1996). Table 4 illustrates the definitions of each of the criterion of interface conformability. To aid conformability, platform providers may offer configuration tools, such as software development kits, and templates to help third-party developers make their technologies compliant (Ghazawneh & Henfridsson, 2013; Wareham et al., 2014).

Evolvability of a platform is dependent on the interface. It is the interface that allows the platform to evolve both at the core and at the periphery level. To do so the interface needs to be designed properly so it reflects the governance mechanisms of the platform owner. If conformable, the interface will reduce the standard tension (Wareham et al., 2014). As a result of conformability the changes of the core will be communicated correctly and thoroughly to the extension developers. This signals stability to complementors which encourages increasing eagerness in joining the platform ecosystem.

The modularity of a platform's architecture is desirable in that it increases the expandability and flexibility of this organizational form. Platform modularity is achieved when core and periphery components are highly independent, i.e., loosely coupled (Sanchez & Mahony, 1996). For this, modules must be designed to be more general, reusable and re-combinable. In contrast, extension modules that are highly specific to core modules, that is, have high synergistic specificity (Schilling, 2000), generate a tightly coupled architecture. While a higher degree of synergistic specificity typically provides a more uniform user experience (as different modules are specifically designed to work together), lower synergistic specificity encourages innovation by stimulating generativity (Schilling, 2000; Wareham et al., 2014).

Lower synergistic specificity is caused by increased modularity (Schilling, 2000). Technological changes call for increased modularity in different layers of service, context, network, and device of a platform (Yoo, Boland, Lyytinen, & Majchrzak, 2012) to increase complementarity and intensifying competition necessary to get broader dynamic coopetition. This increased modularity invites diverse new comers to contribute to the platform periphery. Therefore, increased modularity is not always encouraged by incumbents with the dominant design in the industry. Stronger complementors prefer to keep their positions by enforcing locking effects. When a strong incumbent has difficulty covering all customer join forces with their complementors and offer a bundled software package (Schilling, 2000).In an industry with high heterogeneity of customer demands increased modularity is necessary to serve customers. Therefore customer demand is a

necessary trigger for breaking the inertia and adopting a modular system (Markus et al., 2006).

In an industry with many proprietary solutions, customers need interfaces that glue these software packages together. For example in the case of MSI, an order handling system and an environmental report generator needed to be able to communicate with each other to fulfill the haulers' needs. This need produces niche actors offering interoperability solutions. In face of technological change and transitioning to increased modularity standard interfaces are designed. Increased modularity, thus, will threaten these niche actors' business models as well.

Indeed, shifting coopetitive relationships between diverse actors affect the technology architecture of the platform and vice versa. There is therefore a need for studies that carefully scrutinize such intricate socio-technical dynamics with the ambition to contribute to the understanding on the ways in which platform competition and platform innovation interact over time. A useful theoretical lens to study platforms is Gawer's (2014) integrative framework in that it puts the actors of a platform initiative center stage. More specifically, it conceptualizes platforms as evolving organizations or meta-organization that is characterized by (1) a network of actors that innovate in the generation of value and compete on the for its appropriation of value (Eisenmann et al., 2011; Tiwana, 2015), and (2) a technological architecture composed of a modular core, standardized interfaces, and complementary extensions (Baldwin & Woodard, 2009; Le Masson et al., 2011; Tiwana et al., 2010).

Competition during platform innovation processes emerges usually through technology architecture shifts (Gawer, 2014; Wareham et al., 2014; Saadatmand & Lindgren, 2016). At the same time, cooperation between stakeholders of different structural types, typically having diverging interests, is key to leveraging platform performance (Eaton, Elaluf-Calderwood, Sorensen, & Yoo, 2015; Wareham et al., 2014). Such cooperation is, however, impossible without managerial interventions (Saadatmand & Lindgren, 2016). This highlights the centrality of proper governance of technological platforms and their ecosystems. That is, the platform leader should seek to preserve the alignment of interests of ecosystem members to increase their incentives to innovate in platform enhancing ways (Gawer, 2014; Wareham et al., 2014). Here one pressing issue concerns the establishment of coopetition among actors, leading to concurrent cooperation and competition (Hargrave & Ven de Ven, 2006; Bengtsson & Kock, 2000).

6 SOCIOMATERIALITY

Gawer (2014) highlights that extant research on technological platforms tends to focus on either the economic or the architectural dimensions of platforms (exceptions include Tiwana, 2015; Eaton et al., 2015; Wareham et al., 2014). Such a bifurcated view of platforms makes it difficult to understand the interaction between the social and technological aspects of platforms as organizational forms. In particular, changes to the technological infrastructure frequently generate competitive tensions within and across platforms (Gawer, 2014).

In order to integrate the social and technological aspects of platforms in my study, I engage in sociomaterial theorizing (Orlikowski & Scott, 2008) by highlighting not only that technology has agency and that it is thus capable of generating shifts in the coopetitive dynamics of a platform, but that the social and the material (i.e., hardware and software) are deeply interwoven in the platform's evolution. I therefore adopt the theory of imbrication (Leonardi, 2011), which offers a conceptualization of how the social and the material become interlocked over time. Below I explain the background and motivation to choosing imbrication theory for my analysis.

6.1 Conceptual Foundation

Sociomateriality (without any intervening hyphen) is a concept not specific to IS. It has been discussed in diverse fields, e.g., sociology of science and technology, theoretical physics, and feminist studies. The concept implies that material aspects and social aspects do not have meanings in isolation (Barad, 2003; Barad, 2007; Cecez-Kecmanovic, Galliers, Henfridsson, Newell, & Vidgen, 2014). Sociomateriality consists of the words socio- and material: Latour (2005) states that the word sociality is derived from the Latin word "sequor" which means to follow and this is related to the word *socialis* with the meaning companion. The social word in sociomateriality refers to the relations between people and things and institutional structures and norms that shape these relations.

The word material refers to whatever that constitutes the matter (Barad, 2003). There have been however debates on what "material" really is in the context of technology organizational studies. These discussions stems from the fact that when it comes to the physical technology it is not difficult to point out to the "material" part of it; when we talk about for example a wooden table we can easily state that it is made of wood as the material but

when we speak of a digital technology like a SQL database it is not so straight forward what the material is, following the same logic. In organizational studies, Orlikowski (2007) believes material is:

> "…entailed in every aspect of organizing, from the visible forms – such as bodies, clothes, rooms, desks, chairs, tables, buildings, vehicles, phones, computers, books, documents, pens, and utensils – to the less visible flows – such as data and voice networks, water and sewage infrastructures, electricity, and air system." (Orlikowski, 2007, p. 1436)

Basically Orlikowski believes "material" is whatever that is *left in the office* when the human working with it *has left*. To make the definition of "material" clearer, Leonardi (2012) focuses more on this property of continuity. He believes that "materiality" refers to:

> "… those properties of the artifact that do not change from one moment to the next or across differences in location." (Leonardi, 2012, p. 29)

I believe his explanation makes the definition of "materiality" more tangible. Looking into examples of "material" in sociomaterial studies give a better illustration: Volkoff, Strong, and Elmes (2007, p. 843) in their study of enterprise resource planning software described this system as having "material aspects" like algorithms and features that only users that were assigned special roles were authorized to use them or Orlikowski (2000, p. 406) in her study of groupware software presented it as a technology with "material properties" and she provided examples for those "properties", e.g., Electronic Communication, Text Editing, etc. (p. 414).

Leonardi (2010) argues that if we foreground the fact that things are "made of matter", then we tend to foreground the affordances inscribed in artifacts and the environment. Treem and Leonardi (2012) emphasize that everything that is made up of material has an affordance or multiple affordances through which they can have multiple results; this is in line with Gibson (1979)'s definition of affordances for objects. They formulate materiality as a feature of technological artifact. This technological artifact described as software or hardware feature is connected to the human by the affordances (Treem & Leonardi, 2012).

6.2 Organizational Studies

Orlikowski (2007) pointed out that in organization studies the agency of the technology is avoided and the focus is merely on social interaction by emphasizing the agency of the human factors; while, in reality the social and material are not separable. The social dynamism affects the design of the IT artifact. It is the human agency that affects the affordances and performativity[1] of the technology while in many organization studies researchers tend to treat technology as a tool that does not have agency and has *happened* to the individuals which they need to use and there are different ways of using them. They defined ways to affect the routines of organizations by the effects it has on human based on how the human uses it or avoids to use it (Orlikowski & Scott, 2008; Leonardi, 2010).

This line of thinking simply believes that technology does not have any agency. On the other hand, studies that take the technology into account analyze the social and material aspects completely separately and conclude on the parallel studies of technology and people. However, the social is not separated from the material and neither is material from the social. Therefore the movement of sociomateriality started to inspire researchers to study social and material in an intertwined manner instead of studying these phenomena in isolation. Here however the challenge for scholars has been to understand this composite reality in practice (Cecez-Kecmanovic et al., 2014).

Studies that focus on the intertwined phenomena of material and social stem from the works of Barad (2003) and Pickering (1995). Barad (2003) bases her work on the physicist Niels Bohr's work and presents sociomateriality as a novel way to look into quantum entanglement. Her work follows Pickering (1995)'s ideas on focusing on the fact that the phenomenon we observe is entangled with the apparatus for observation and with us as observers. In his work, Pickering (1995) explains this entanglement by arguing that quarks exist as a result of a series of physical experiments and the experiments are designed to observe the quarks.

Different adaptations and developments of sociomaterial views do not follow the exact same paths, however. Suchman (2007) believes that there is no material or social agency but a sociomaterial agency and therefore it is the

---

[1] The notion of performativity can be traced back to Austin's speech act theory, where a verbal utterance has performative effects i.e., is part of doing an action. For example, a couple is married when the registrar utters the words "I hereby declare you man and wife" (Austin, 1962)

sociomaterial that should be chosen as unit of analysis not only the social or the material. Following agential realism Suchman (2007) criticized that human and technology are studied separately in Human Computer Interaction (HCI) field and instead called for analyses that look into human and computer as mutually constituted. Inspired by works of Barad (2003), Doyle (1997) and Haraway (1991), she sees the intertwining of human and material as sociomaterial assemblages and argues that:

> "Agencies – and associated accountabilities– reside neither in us nor in our artifacts but in our intra-actions." (Suchman, 2007, p. 285)

She consequently sees human and technology inseparable. Orlikowski (2007) expresses the same criticism toward organizational studies and calls for analyzing organizations by looking at technology and human as sociomaterial constitutive entanglement. This entanglement is described by her as:

> "There is no social that is not also material, and no material that is not also social." (Orlikowski, 2007, p. 1437)

To explain this entanglement she uses Google's PageRank algorithm as an example. She elaborates that this algorithm counts the visits to a page; this rank determines the place of this webpage in google result when the user is searching for a content related to this page. Simply the higher the rank the higher the place of the webpage in the search result. The place of the webpage in the result page is not static but changes over time based on how many "clicks" it gets. The algorithm also makes exceptions based on the regulations of the country the search is being done from, e.g., the Chinese google is obligated to censor political pages from the opposition (Orlikowski, 2007). These dynamics, Orlikowski (2007) argues, make the search results sociomaterial:

> "These temporally emergent results are not dependent on either materiality or sociality, nor on some interaction between them (to the extent that these are seen as distinct domains). Rather the performance and results of a Google-based search are sociomaterial." (Orlikowski, 2007, p. 1440)

This perspective of interlocking forces helps explain that smartphones' physical and functional features do not only materialize ideas of instant and ubiquitous communication, but also produce users who check their messages constantly and feel compelled to respond to them immediately, whether during or outside of work hours (Orlikowski, 2007). While such new

smartphone-enabled communication practices imply that users exercised their agency in appropriating the technology in this way (as opposed to resisting it), a sociomaterial lens nevertheless highlights that "technological actors constitute us even as we try to constitute them" (Introna & Hayes, 2011, p. 110).

Inspired by Barad (2003), Orlikowski follows the same thinking as Suchman (2007) and call for studies of entanglement of social and material focusing on bringing forth the sociomaterial nature of subjects of studies in organizational works. While Sassen (2002; Latham & Sassen, 2005) and Leonardi (2011) presents the notion of imbrication to study the overlapping nature of human and material agencies arguing that social and material become sociomaterial when they are interlocked (I will give deeper explanations of the imbrication in the next chapter).

The challenge for IS scholars has always been to be able to analyze the real examples of practice via sociomateriality theory and understanding and analyzing "the recursive intertwining of humans and technology in practice" (Orlikowski, 2007, p. 1437). Mutch (2013) blames the agential realism view of sociomateriality for this shortcoming stating that removing agency from social and material makes it difficult to study sociomateriality in practice; while Leonardi (2013) believes that agential realism approach suits some studies, e.g., the case of TripAdvisor (Orlikowski & Scott, 2015) but it can be an ill fit for other studies, e.g., the case of CrashLab (Leonardi, 2011). Therefore, Leonardi (2013) and Jones (2014) suggest critical realism as an alternative choice for studies of sociomateriality. A sociomaterial framework based on critical realism perceives an organization structure in two realms of action and structure there realm of structure points to materiality and realm of action points to the social aspect of the organization. These two different realms are not separated but "imbricated" into each other. Over time these imbrications represent a cumulative entanglement of social and material. In chapter 7, I explain agential and critical realism more comprehensively.

7 IMBRICATION FRAMEWORK

The sociomateriality Barad presents follows agential realism. She believes human and material are entangled and any distinction the researcher makes to them to separate them is an "agential cut" (Barad, 2003, p. 815). Following Barad's line of thought agential realism sees agency in the relationship of human and material but because this deeply entangled relation can be too complicated to analyze researcher makes "agential cuts" to ease the observation. This solution however has not solved the problems researchers are faced in applying agential realism while analyzing sociomaterial phenomena.

7.1 Agential Realism or Critical Realism

Three main problems with agential realism are pointed out mainly by Mutch (2013) followed by Leonardi (2013):

> 1. Lack of explanatory power that leads to more descriptive studies instead of deeper empirical analysis.
> 2. It poses problems in analyzing real life cases because people in practice rarely perceive social and material as "interpenetrated entities" as they are presented in the agential approach (Leonardi, 2013, p. 66).
> 3. Agential approach does not consider time which poses problems in analyzing change and evolutions in organizational structures. This can be because the root of sociomateriality comes from Barad's work on physics; in physics applying any process theory might not be necessary or of interest while time and analyzing changes with a process theory is in the core of organizational studies.

To solve these problems that stem from the agential realism view, critical realism is prescribed (Mutch, 2013; Leonardi, 2013). Critical realism, in contrast with the agential view, believes that social and material are not intertwined but are separated and get entangled in relationship with each other affected by human activity. Consequently, critical realism does not take away the agency from the human and/or the technology. This negates the belief agential realism pursues that social and material are interpenetrated independently from human activity over time. Agential realism makes no distinction between social and material while critical realism approach to

sociomateriality treats materiality as an independent entity (Mutch, 2013). Leonardi (2012) defines material and social in critical realism approach as:

> "…whereas materiality might be a property of a technology, sociomateriality represents that enactment of a particular set of activities that meld materiality with institutions, norms, discourses, and all other phenomena we typically define as 'social'." (Leonardi, 2012, p. 34)

With regard to analyzing the social and material relationship Leonardi (2013) explains:

> "Social and material agencies are distinct from one another, and it is only once they become imbricated in particular ways that they can then reconfigure technology's materiality and organizations' communication patterns" (p. 70).

Leonardi believes that critical realism gives the researcher tools to analyze the sociomateriality by giving her the temporality and the possibility to be able to look into the development of the imbrication over time; this is how she can see the effect of different agents of material and social through the imbrication to be able to draw conclusions. The agential realism sees sociomateriality only in the realm of action which makes it difficult to analyze the organizing when looking into the empirical from this point of view (Leonardi, 2013/2012). To solve this problem critical realism looks into both action and structure realms: It puts materiality into the structure realm and social in the action realm and the communication between two is seen as what Leonardi calls imbrication, or in other words:

> "… actions' slow but cumulative entanglement with structure (and vice-versa)." (Leonardi, 2013, p. 72)

Researchers find sociomateriality a rather philosophical approach (Leonardi, 2013) and still struggle to apply the method to analyze the sociomaterial nature of IS organizations (Cecez-Kecmanovic et al., 2014). One of the reasons is that there are not so many empirical accounts on analyzing organizations by focusing on the sociomaterial aspects of the IT and decisions in the organization. Leonardi (2011) however offers a detailed analysis of the case of CrashLab there a computer simulation technology for automotive design was used to show the recursive intertwining of technology and people in practice in form of imbrications. His imbrication framework suggests that when technology helps human to gain her vision technology manages by its affordances to change human's routines; on the contrary,

when technology does not help human to get to her vision this constraint cause human to change the technology instead.

In his analysis of the case of CrashLab, Leonardi (2011) follows a critical realism approach and gives agency to both human and material in compare to agential realism that sees the agency merely in the relationship of the two. He believes that critical realism and focusing on affordances and constraints of the technology help him to analyze the two competing forces of sociomateriality separately and bring that analysis to studying their relationship to be able to understand the evolution trajectory of CrashLab.

In analyzing MSI one of the most pressing issue is time because the evolution and changes over time plays a crucial role in how the coopetition and technological shifts unfolded therefore a methodology with temporal aspect was necessary. Further, during the analysis of actors and technology comprising the platform it was key to be able to analyze the human reactions to technological shifts and how technology contributed to moving the initiative toward the collective consensus and diffusion. In the MSI case both actors and the technology had agencies before entanglement was formed. Therefore I find critical realism and imbrication account in particular suitable for my study.

7.2 The Imbrication Framework

The word imbrication has its root in the structure of imbrex and tegula (Figure 4).

> "Each tegula (a) overlaps the one below it and its raised lateral borders tapering in to nestle between its lower tile's upper border. Each curved imbrex (b) covers the side ridges of the joints formed between adjacent tegulae. Some imbrices are not shown in order to reveal the details of the tegular joints."("Imbrex and tegula," 2017)

Imbrication is the technique of interlocking the imbrex and the tegula to make tenacious and robust roof coverings in ancient Greek and Roman architecture (Leonardi, 2011).
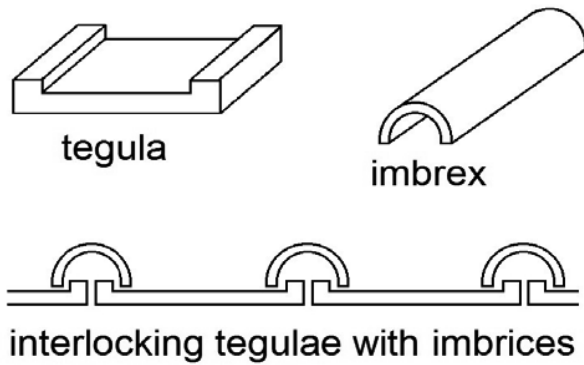
Figure 4 Imbrication of Imbrex and Tegula

*([Untitled illustration of imbrex and tegula]. Retrieved August 2, 2017
from http://sidingcontractors.us/roofing-materials/imbrex-tegula/)*

Inspired by Imbrex and tegula shapes, Leonardi (2011) represents the social or organizational routines as the imbrex and the technology as the tegula in each imbrication pattern. He explains the interlocking pattern by vividly illustrating how the social (i.e., organizational routines) changes the technological settings and how the new affordances of the "changed" technology recalibrate the organizational routines.

In imbrication social and material are encouraged to get examined separately but related to each other via social actions. Technology, in imbrication form of sociomateriality, is seen as the result of "social, economic, political, and cultural dynamics" (Latham & Sassen, 2005, p. 14) which Leonardi (2011) calls human agency. Leonardi (2013, p. 72) presents imbrication as two different realms of "action" and "structure" that are related to each other in an imbricated manner resulting in "cumulative entanglement".

Giddens (1984) defines agency as the "capacity for action". Human uses its agency toward realizing her goals and intentions through cognitive processes. Human uses its goals as the motivation and manipulates its environment to achieve them. She monitors the environment frequently to determine if her goals are met (Leonardi, 2011). While one of these tools for the human to alter her environment is the technology, technology has agency that "cannot be reduced to human intentionality" (Leonardi, 2011, p. 150). In imbrication theory, just like actor-network theory (Latour, 2005), the technology agency is treated equivalent to human agency. In the same vein, Taylor, Groleau, Heaton, and Van Every (2001, p. 71) believe that the agency of the material

45

should not be seen as a "complement" to the main agency, i.e., the human agency but it has to be given its own.

One of the main believes in imbrication is that the social precede the material by explaining technology as "outcome of the social" (Latham & Sassen, 2005, p. 14) and that human agency shapes and chooses the technology based on her need (Leonardi, 2011). It, however, does not mean that this school of thought treats technology as passive and manipulated by the social. Imbrication treats technology as a strong agency which allows the social to achieve its vision and shapes the empirical phenomena through getting interlocked in sequences of interaction with the social. Latham and Sassen (2005) emphasize developing analytical tools that pay more attention to the technology is the way to understand complexity of sociomaterial phenomena.

Imbrication theory maintains that when human and technological agencies are put together into an overlapping arrangement (i.e., imbricated), they create technologies and routines. Routines (i.e., "sequential patterns of social action" (Leonardi, 2011, p. 148)), and technologies, in turn, imbricate to form an infrastructure that will determine whether the technology is seen as either affording or constraining the ability of users to exercise their agency. For example, in light of established norms of consultative selling, sales associates in an insurance marketplace found it difficult to pursue their goals of maintaining embedded relationship with their customers when self-service technology was implemented (Schultze & Orlikowski, 2004). Thus, in the context of the sociomaterial infrastructure of consultative selling, self-service technology constrained human agency (i.e., the sales associates' goals).

Leonardi (2011) in his analysis of CrashLab gives a thorough imbrication analysis of how the interlocked sequences between the organizational dynamics and technological adjustments shaped CrashLab over the years. His work so far is the only imbrication work with tangible detailed analysis of the empirical relying on imbrication thinking. In his work he shapes the analysis in sequences of "Human to Material" and "Material to Human" representing social that changes the material and vice-a-versa.

An imbrication perspective seems well-suited to analyzing the longitudinal nature of the empirical setting I explore in my dissertation. The theory of imbrication maintains that human agency (i.e., the ability to act with intentionality, motivation and rationality) and technological agency (i.e., "the capacity for nonhuman entities to act on their own, apart from human intervention" (Leonardi, 2011, p. 148)) form the building blocks of practice.

Human agency, following her incentives, uses the affordances technology offers to achieve her goal. This does not mean that the technology has one specific affordance or set of affordances designed specifically to gain a predefined goal but it projects different set of affordances for different contexts. A very simple example to further elaborate can be Microsoft Word; this technology can be used to write an essay, present the items of a warehouse in a table, or draw illustrative diagrams. It is the human that chooses the affordance that leads her to her goal. This example shows that the affordance of the technology can change across contexts while the materiality is untouched.

In the imbrication framework when an existing material agency affects the human by shaping new routines, it is shown as *material to human* or *material→human.* This specific affordance gives human a new agency. The action of the human choosing a specific affordance in the technology is defined as *human to material* or *human→material.* By choosing that specific affordance, human gives material a new agency. The new material agency changes the human routine and social interactions. What is important to take into consideration is that an imbrication is not the result of its current changes either human to material or material to human but it is the result of the history of imbrications that has occurred prior its existence (Leonardi, 2011).

In addition to identifying the conditions under which technologies become either affordances or constraints, the theory of imbrication maintains that configuration of human and material agency at any given point in time, will determine whether people will change the technology or change their routines. Specifically, when the technology is regarded as an affordance, that is, an action possibility for a specific user in a specific context (Gibson, 1979), a sequence of imbrications that changes what people do is set in motion. In contrast, when the technology is perceived to be a constraint, a sequence of imbrications that changes the technology is generated.

This pattern of how technology and human agency interact must, however, be understood in light of imbrication theory' key assumption that technology - not just routines - are flexible. This flexibility is not just a matter of the technology's materiality (e.g., the modularity of its architecture), but also an organizational "context where people can have it modified to fit their needs in relatively short order" (Leonardi, 2011, p. 149). The MSI case study of a shared industry platform's development thus meets the theory's boundary conditions.

8 RESEARCH SETTING

My research is based on a twelve-year (2002-2013) shared platform initiative within the Swedish road haulage industry that led to a new technology standard for integration of stationary enterprise systems with emerging embedded and mobile technologies. From the outset, the project was designed as action research based on established traditions within the IS discipline (Baskerville & Myers, 2004; Lindgren, Henfridsson, & Schultze, 2004; Mathiassen, 2002; McKay & Marshall, 2001; Susman & Evered, 1978).

In what follows, I introduce the problem setting in which the project unfolded by offering an explanation of the IT support for Swedish Haulers, IT implementation problems for them, The vision of a shared platform, MSI initiative and the Development process. This background of the case serves to illustrate Swedish road haulage industry before and during the shared platform initiative in general, and the importance of initiating a shared platform in particular. It also gives an overview of the MSI initiative and the sequence of events. The four upcoming sections are designed to prepare the reader for the detailed analysis that I will present in chapter 10.

In the late 1990s, the Swedish road haulage industry consisted mainly of small local firms with deep-rooted traditions (Andersson & Lindgren, 2005). Statistics from the Swedish Road Haulage Association (hereafter SRHA) suggested that up to 90 percent of its members operated five or fewer vehicles. The European Union's open market policy had just allowed foreign road haulers to increase their market share in Sweden. As a result, increased competition from Danish, German, and Polish firms lowered profit margins and large global firms like Danzas and Schenker strengthened their market positions.

8.1 IT Support for Road Haulers

Stationary planning systems and mobile phones had for long been used to manage road transport. However, Swedish road haulage firms believed embedded and mobile technologies could help them coordinate better to cope with the increasing competitive pressures. Fueled by trade press articles and white papers, these companies anticipated increased digitalization would improve mobile resource evaluation, facilitate seamless transport data management, and rationalize dispatcher-driver communication. IT vendors and truck manufacturers also promoted increased digitalization as the next

step towards sustainable business processes in haulage firms. Referring to their R&D investments, they predicted most firms would soon rely on these new digital opportunities.

However, there were few available accounts of how assemblages of embedded, mobile, and stationary technologies had led to productivity gains or improved sustainability. In fact, at industry conferences and seminars, the SRHA complained about low penetration of advanced distributed technology among its members. Primary interviews with road haulers also clearly indicated that infrastructure initiatives often faced complex challenges because of the heterogeneous and distributed nature of technologies, organizations, and practices. Apparently, it was hard to transform these socio-technical assemblages, and many firms felt they wasted their money. As a result, there was decreasing willingness to make proactive IT investments amongst small road haulage firms.

Hence, road haulers continued to rely on fragmented infrastructures that prevented productive combination of embedded, mobile, and stationary systems. This 'mobile-stationary divide' was reinforced by several players: 1) truck manufacturers offered embedded solutions dedicated to their brand; 2) vendors offered stationary solutions based on proprietary interfaces and standards; 3) contractors of haulers provided mobile and stationary solutions dedicated to their specific information management needs, and 4) The SRHA propagated a lightweight solution without integration capability to other available IT systems. If small haulers wanted to move from heterogeneous portfolios of IT solutions to integrated digital infrastructures they had to deal with different interfaces and standards and negotiate with many different technology users and providers. That meant they needed to engage in many data interchange activities manually to get the systems to work. Moreover, they needed to understand how strategic decisions and contextual factors would shape the complicated process of aligning interests to achieve a dominant technological design. It all had contributed to the extremely slow IT adoption among haulers.

Road haulage firms typically consist of mobile field operations and stationary headquarters. Digital infrastructures for such organizations therefore contain embedded, mobile as well as stationary computing resources (Andersson & Lindgren, 2005; Lindgren et al., 2008). The corresponding technological realms are commercial telematics, nomadic devices, and administrative enterprise planning. Embedded systems serve different purposes for various users. Services that utilize vehicle data to display feedback metrics on the performance of the vehicle for the driver may, for example, raise awareness

of fuel consumption. Management responsible for fleet performance can use the recorded digital traces of fieldwork to minimize the cost of a transport assignment in terms of time and fuel expenditure. Stationary systems help dispatchers remotely coordinate assignments via displaying the positions of each truck and by communicating associated information to drivers via integrated mobile systems. Embedded GPS-based positioning systems enable dispatching and in-vehicle navigation services. Table 5 presents a summary of classes of IT support in road haulage firms.

Table 5 Classes of IT support in road haulage firms

Class	Infrastructure	Functionality
Embedded systems: aimed at improving the efficiency of vehicles/drivers	• Active ignition sensing software • Barcode scanners • CAN-bus • GPS receiver • RFID technology • Trip recording software	• Breaking and shifting behavior analysis • Driver working time analysis • Driving and stopping times tracking • Fuel consumption and trip distance monitoring • Information about mobile workers' positions • Maintenance planning • Navigation support
Mobile systems: aimed at improving the efficiency of mobile workers	• Nomadic devices in cockpit (coupled to vehicle electronics) • Vehicle-mounted communication terminals (share platform with vehicle-centric applications)	• Verbal communication between stationary personnel and mobile workers • Remote access to stationary planning systems • Text messaging
Stationary systems: aimed at improving the efficiency of dispatchers/managers	• Geographical information systems • Fleet management applications (integrated with ERP software)	• Event-triggered alerts and geo-fencing • Geo-positioning • Order management • Route optimization • Cargo and vehicle monitoring and tracking

In 2002, Vehco (a start-up in embedded technology) approached Viktoria Institute to discuss research collaboration aimed at digital infrastructure innovation within the Swedish road haulage industry. Vehco competed with truck manufacturers' telematics services and wanted to refine its core competence, namely leveraging technology embedded directly into vehicles to support management of small road haulage firms.

By teaming up with Viktoria Institute's Telematics Group and its expertise in digitalization of transport practices, Vehco hoped to generate breakthroughs on how to develop digital infrastructures for small road haulers by integrating embedded technology with mobile and stationary technologies. As a result, Vehco and the Telematics Group initiated the MSI action research project. The project started with interventions into selecting road haulage firms and continued to enroll multiple stakeholders to increase the efficiency and sustainability of road hauling operations through standardized usage of IT. These actions sought to reveal the involved politics and to maximize the innovation potential by scrutinizing how actors had generated and shared knowledge to develop digital infrastructures in the past. In the next section, I explain how a typical scenario in a hauler's work looked like in the beginning of the MSI project.

8.2 Implementation Problems

In a typical scenario a hauler that owned a number of trucks (varied based on the size of the hauler) would be assigned a transport job. If a hauler had enough resources it would initiate the transporting process by assigning the task to the right truck/driver. This assessment and task dedication happened largely manually at the time (late 90s and beginning of 2000s). A person called the dispatcher would assess the suitability of a truck for the task based on a manual calculation she would do and she would delegate the job to the driver mostly by phone or a walkie-talkie.

The high point of technology use in such process was the use of Excel at the time. If the hauler realized it did not have the resources to cover the task; in some cases it would outsource to a similar kind of hauler that did similar kind of goods transport. Although such haulers would be direct competitors they would do each other such "favors" in order to avoid losing their customers. This pairing could happen simply out of acquaintance of different haulers or a hauler would get such available hauler's information from SHA(Swedish Hauler Association).

Some haulers, however, were not allowed to do such exchanges with any hauler available. These haulers were part of a Logistic Broker (LB), e.g., DHL and were bound to work only with haulers that were members of the same LB. These haulers could not use the available software packages on the market but they had to rely on their internally developed software especially tailored for the LB. Figure 5 illustrates the haulers relationship and their use of software packages.

Goods   Haulers   Software Packages

G1 → H1

G2 → H2

G3 → H3

*

H4

Hm

Gm → Hm+1

Gn → Hn

DATA CONVERTING

Hn: A hauler that has some amount of trucks
*: A set of haulers as members of a Logistics Broker

△ Software vendor
▱ Truck manufacturer

Figure 5 Systems integration in haulers

The entire transport process from door to door engaged different digital infrastructures that more often than not were disintegrated burdening the haulers' office staff with data converting between different software, making the process error-prone at best. Integration projects had started between some companies. Although in the beginning of the MSI, integration projects made it easier for IT vendors to communicate, but they were isolated leaving haulers with different software packages that covered different part of the transport work process. In the next section, I continue the explanation of the initiative by Vehco and Viktoria. I give an overview of the MSI vision and industry actors' motivations.

8.3 Shared Platform Vision

Vehco's effort to establish collaboration with the Telematics Group was well aligned with Viktoria Institute's agenda to pursue design-oriented applied research within the transport industry. As a spin-off from Chalmers University of Technology, Vehco was still seeking funding for R&D activities and its shared platform strategy seemed feasible and attractive for the industry. A series of meetings about possible venues of joint interest resulted in a partnership to kick-start R&D efforts into digitalization of Swedish road transport.

Although Vehco had a number of customers, the MSI project needed to engage a broader group of road haulers. The SRHA was a natural partner and contacts to them provided a deeper understanding of the actual state of IT use within the industry. Road haulers could rarely afford to develop custom built systems, so they typically adopted various off-the-shelf solutions. This was problematic especially for small firms. While these solutions did not cover the wide variety of business activities in road haulage, the consequential heterogeneity in technologies and vendors required IT competencies most firms did not have. As a result, the MSI project decided to focus on helping small road haulage firms address their socio-technical struggles.

Initially, the researchers analyzed available IT solutions and core vendor competencies, which turned out to be more complicated than anticipated. In fact, stationary technology vendors tried to include mobile resources (drivers and vehicles) and embedded technology vendors (including truck manufacturers) increasingly embraced traditional stationary domains. Based on visit to the annual trade fair and numerous meetings with technology vendors and truck manufacturers, the researchers distinguished between three types of systems: embedded, mobile, and stationary. Interestingly, the vendors were technology-focused and promoted their solutions relative to competitors rather than in terms of hauler requirements and added value. It was therefore difficult for small haulers to identify gaps and overlaps between different solutions, effectively hampering attempts to combine solutions.

The next critical step was to analyze the status quo in road haulage firms. Supported by the SRHA and Vehco, the researchers interviewed managers from 20 road haulers about their IT experiences. The problem of lock-in effects kept surfacing in these conversations. On one hand, fleets with vehicles from multiple manufacturers were common and integrating different embedded and mobile components with the stationary systems was

prohibitively expensive for small firms. On the other hand, although vendors were confined within their own technological paradigm and unable to comprehend wider design challenges, they actively promoted their solutions outside their core competence to increase market shares. This led to a persistent problem within the Swedish road haulage industry with failed IT implementation projects as haulers attempted to implement services offered by embedded, mobile, and stationary technology vendors in parallel.

Based on this initial understanding of the socio-technical factors that contributed to the mobile-stationary divide in road haulage firms, the MSI project concluded that IT vendors and haulage firms should meet to discuss industry concerns. This resulted in two seminars organized by the SRHA, Vehco, and the Viktoria Institute during fall 2002 to discuss insights from the researchers' interactions with IT vendors and road haulage firms. The seminars were fairly well attended but did not stimulate collaboration initiatives and innovation.

In parallel, the researchers (including MSc students) engaged in small-scale shared platform service prototyping activities with Vehco. Ultimately, they sought to inform an agenda for integrating embedded, mobile, and stationary systems in the road transport industry. Drawing on previous studies, they developed a number of prototypes, which was designed to couple on-line readouts on fuel consumption embedded within vehicles with stationary transport data. Despite its somewhat limited design, the prototype rendered much interest when presented at industry conferences and seminars. However, some technology vendors criticized that the design of the service was restricted to a single system vendor (and a particular road haulage firm), but still they expressed willingness to participate in a continued R&D effort.

Hence, the local interventions at Vehco created opportunities to pursue a larger, more sustainable shared platform initiative. A key goal would, on one hand, be to help vendors abandon prevailing technology-driven approaches in favor of ones oriented towards meeting hauler needs and expectations. On the other hand, it was important to strengthen the position of small road haulage firms by helping them implement assemblages of embedded, mobile, and stationary technologies in more flexible ways. The initiative therefore had to accommodate the heterogeneous interests of technology vendors and road haulers alike.

The fragmentation of IT support for road haulage firms was a result of institutionalized vendor behavior. Most of them were reluctant to share and rethink their business strategy and that undermined their ability to participate

in some form of collective action. In that situation, it was virtually impossible to initiate cooperation between competing vendors that promoted different and in many respects incompatible IT solutions. A critical next step was therefore to expand the platform initiative to start changing the relationships and structures that kept different technology vendors apart. Over a period of six months, the MSI project focused on this challenge through explorations with IT vendors, road haulage firms, and truck manufacturers. finally, an ecosystem of dominating industry players was in place. Besides Viktoria Institute and Vehco, the founding members were Hogia, NL Partner (was acquired by Locus Scandinavia in late 2005), Scania, and Volvo. All actors believed the arrangement was necessary to establish the inter-organizational processes required for continued industry digitalization. The platform initiative was formalized in a researcher-client agreement to secure commitment and specify roles and responsibilities.

A government agency (VINNOVA) provided funding for the collaboration through the project "Value-Creating IT for Road-Haulage Firms" As a first step, the partners decided to focus on reuse and reconfigure architectural knowledge from already established projects that aimed at integrating embedded, mobile, and stationary technologies into coherent digital infrastructures. The researchers identified seven ongoing integration projects, and the other platform members provided access to their most advanced cases of heterogeneous technology integration, in effect transcending the long-standing tradition of vendors black boxing their integration procedures. The considered projects were generally quite modest in terms of technological innovation, and it became clear that simply reusing and reconfiguring architectural knowledge from different vendors would have a limited effect. In fact, all projects had failed to successfully integrate the involved heterogeneous technologies because of lack of knowledge sharing suggesting that no single vendor had the capacity to develop a comprehensive digital infrastructure of embedded, mobile, and stationary systems. Although some platform members still preferred to work on their own, most of them realized their inability to handle technologies outside their core competency, especially in situations involving technology embedded into vehicles. Hence, the discussion of lessons across integration projects had started to move competing vendors towards closer cooperation.

The researchers' continued analyses of the integration projects showed how proprietary interfaces both supported and inhibited cooperation amongst vendors and haulage firms. The fact that the IT vendors had created the interfaces suggested they realized a need to develop digital infrastructures that integrated components from diverging sources. Although the vendors

would not be able to control such development to strengthen their competitive positions, the interfaces expressed a readiness to engage in efforts to support systems integration. But, the different proprietary interfaces also adversely affected cooperation opportunities. These interfaces were published by stationary vendors to allow their embedded and mobile counterparts to connect to their solutions. So, embedded and mobile vendors had to comply with the interfaces if they wanted to help haulers establish integrated digital solutions. Reflecting the technological frames and market strategies of the vendors of stationary technology, the interfaces offered elaborate support for the stationary systems. In contrast, they provided virtually no support for mobile and, particularly, embedded technology and they were therefore at the heart of the mobile-stationary divide that effectively separated relevant actors. Further explorations suggested that vendors of embedded technology also adopted protective strategies to maintain their competitive positions. Several road haulage firms were not able to evaluate truck performance via their PC-based fleet management systems because inclusion of vehicle sensor data, such as fuel consumption, was hindered by proprietary interfaces. As a result, it was difficult to promote sustainable transport solutions. Insight into these problems with proprietary interfaces further stimulated the members of the platform initiative to create better knowledge sharing opportunities amongst vendors and road haulers.

In addition, the researchers also sought to maintain the commitment from the SRHA and to enroll select individuals with requisite architectural knowledge about the digital infrastructure challenge. The researchers therefore attended a number of meetings with the SRHA IT forum to discuss socio-technical issues related to technology integration. Although the expert groups within SRHA appreciated the insights from the researchers, the interactions did not lead to intensified support from the SRHA. However, the researchers still believed a skillful and experienced digital infrastructure person without any ongoing commitments to the involved partners could potentially play a vital mediating role. They had for a while attempted to identify such a person, when a former telematics manager at Scania unexpectedly contacted them. He was at the time running his own business, ASN IT & Management, offering education about transport process innovation through standardized systems integration to individual road haulage firms and regional road haulage associations. Given his interest and background, he was invited to join the shared platform initiative to guide the platform group toward a proper architecture choice.

8.4 MSI Initiative

Historically, the lack of standardized interfaces for integration of embedded, mobile, and stationary IT systems has undermined Swedish road haulage firms' attempts to innovate digital infrastructures (Andersson & Lindgren, 2005; Lindgren et al., 2008). While lock-in effects of proprietary interfaces created gaps between social and technical elements within firms, they also hindered inter-organizational partnership arrangements. As a result, it was difficult to reduce CO_2 emissions by improving fleet utilization and implementing flexible logistics operations.

To break with the dominating proprietary agenda, the rationale behind the reported shared platform initiative was that assemblages of embedded, mobile, and stationary technologies (paired with behavioral improvement) have the potential to curb some of the environmental impacts of road transports (Andersson et al., 2008) and facilitates digitalization of road haulers' workflows. Consisting of highly heterogeneous social and technical components with complex dependencies, however, such assemblages must be managed through well-defined standardized interfaces between constituent layers (Tilson et al., 2010). Accordingly, in the MSI project the developed interface can be classified as a vertical technology standard to allow transport processes within and across individual road haulage firms to achieve desired outcomes. These standards prescribe data structures and definitions, document formats, and business processes for particular industries (Malhotra et al., 2007; Wigand et al., 2005ab). Bala and Venkatesh (2007, p. 341) note that such standards "not only specify and define the structure and format of business messages through a common language but also orchestrate the message exchange choreography, i.e., sequence of steps required to execute an atomic business process among trading partners".

The MSI project was initially led by the Viktoria Institute, a research-focused consulting organization whose customers included mostly transportation companies and automobile manufacturers. The transport industry network on whose collaboration the Viktoria Institute relied, consisted of nineteen technology vendors (Addmobile, Barkfors, Consafe Logistics, Cybercom Group, Gatespace Telematics (Later changed to Makewave), DPS, Halda, Hogia, IBS, Prolog, NL Partner (Later changed to Locus Scandinavia), MobiOne, Mobistics, Pocket Mobile, Systeam, Netlink, Transics, Transware, and Vehco), two truck manufacturers (Scania and Volvo Trucks), a number of road haulage firms, and TRB, a consulting organization owned by fifteen Swedish transport organizations (see table 6 for a classification of the actors in the MSI project).

Table 6 Stakeholders in the shared platform initiative

Actor category		Actor names
Embedded technology providers	Truck manufacturers	Scania, Volvo Trucks
	Vehicle Telematics	Drivec, Gatespace Telematics, Transics/BNT, Vehco
Mobile technologies providers		Barkfors, Consafe Logistics, CyberCom, DPS, Halda, MobiOne, Mobistics, Pocket Mobile, Systeam
Enterprise Resource Planning (ERP) system providers		Hogia, IBS, NL Partner (later Locus Scandinavia), Prolog, Transware, NetLink

The industry actors brought considerable experience with embedded, mobile, and stationary technology to the project. The action researchers brought previous experience with design-oriented action research (Lindgren et al., 2004) and embedded and mobile computing (Henfridsson & Lindgren, 2005).

Following Avison et al.'s (2001) classification of authority and control, the project structure was staged with shifting power dominance between the participants. Although the researchers initiated the project, the authority was assigned to a team consisting of practitioners and researchers once the Client-Researcher Agreement (Davison, Martinsons, & Kock, 2004) was signed. The project was coordinated by different researchers, but as the project progressed control was increasingly dominated by industry interests. While the project spanned over almost twelve years (2002-2013), I have included its aftermath by extending the study period to the summer of 2016.

The potential reduction in fuel consumption was the main environmental benefit directly associated with the MSI shared platform. It was recognized

that fuel consumption and associated CO_2 emissions can be reduced in three distinct ways (Andersson and Lindgren 2005): 1) enhanced driving behavior (e.g., minimized idling time); 2) optimized route guidance; and 3) improved cargo planning (e.g., fully loaded trucks). These measures could enable road haulage firms manage their truck fleets to become more environmentally friendly. By the same token, these actions promised to generate new digital options and associated business opportunities for technology vendors as the innovation orientation of the action research sought to anticipate tomorrow's needs to help create a technologically superior industry standard (Andersson et al., 2008). Accordingly, the developed MSI standard as part of the MSI shared platform (Table 7) can be classified as a vertical IT standard to allow transport processes within and across individual road haulage firms to achieve desired outcomes.

The insights gained from analyzing ongoing attempts to integrate technology in road haulage firms provided a valuable foundation for future actions. Specifically, it had created an organizing vision that cooperation across competing vendors and road haulers was needed to overcome technological lock-in and counterproductive business strategies. Specifically, it was assumed that increased networking and sharing based on public debates would make the haulers a more potent group of actors. At this point, the action researchers believed the platform initiative could stimulate a "best of breed" technology market and they therefore started to enroll additional vendors into the network. The goal was to expand the ecosystem so that it represented the main part of IT vendors operating in the Swedish road haulage industry at the time.

In 2004, a telematics manager from Volvo presented his vision for the future of the road haulage industry in which he asserted that the emerging digitalization had reached a point of no return. Well aware of Volvo's own problems to build business around embedded technology in its vehicles, he predicted that the already limited IT investments made by road haulers could be reduced even more. What was required was a market place for service innovation that would operate based on modularized digital infrastructures enabled by standardized interfaces. As he was impressed with how the platform initiative had developed its activities and participation, he suggested the timing was right to pursue an effort to create the foundation for such a market place. All involved parties appreciated Volvo's call for standard development and it was particularly important that some of the stationary technology vendors agreed a standardized industry interface could help resolve the tensions surrounding integration of embedded, mobile, and stationary systems.

The platform initiative sought more support from the SRHA, but it turned the invitation down due to competence and resource shortages. The leadership triggered a renewed search for key individuals that could help move the standardization efforts forward. This led to explorations between the action researchers and several individuals with established industry relationships and sympathy for the shared platform agenda. One such individual was a PhD candidate of the Logistics & Transport research group at Chalmers Technical University who was acting as the IT coordinator of TRB Sweden. Enrolling him into the initiative provided access to relevant knowledge about digital infrastructure within the Swedish road haulage industry and it created an important formal link to TRB and many road haulage firms. Thus, the standardization effort started to move forward and the vendors became increasingly enthusiastic. They knew TRB had successfully represented the road haulers in political negotiations about environmental regulations and transport policies and they therefore believed the extended initiative was a viable arena for development of an industry standard.

The shared platform initiative was now focused on promoting transport innovation through integration of embedded, mobile, and stationary systems and with the specific objective to develop the MSI standard (Table 7). As a result, they formed the MSI standardization group led by one researcher and composed of technical staff from the member vendors. A key task for the group was to specify a common business terminology for system-to-system communication of transport activities. The researchers' analyses had shown that existing stationary vendor interfaces lacked specifications outside the stationary context such as fuel consumption metrics and working hour data. While this partially explained why these interfaces rarely supported practical integration efforts within road hauler firms, it also meant that the standardization group could not rely on the existing interfaces. As a result, the ASN IT & Management representative took initiative to analyze the Pharos mobile standard, which targeted business processes for larger contractors of haulers rather than small haulage firms. Although it would add a new level of complexity to rely on the Pharos mobile standard, one important conclusion was that the MSI standard should be based on XML to maximize its diffusion potential. Fortunately, some of the involved vendors had used XML to specify their interfaces and more were in the process of adopting XML. The standardization group therefore decided to develop the new technology integration standard based on XML.

Table 7 The MSI shared platform

Vision

A modern truck contains technology to sense its state and make vehicle-related data available via the built-in CAN bus. Telematics software also includes a GPS chip so that a position can be attached to each data point. The vision of the MSI project was remote real-time access to the connected truck. Such connectivity caters for data about driver times, engine temperature, fuel consumption, gearshift patterns, geographical location, idling time, maintenance timing, oil pressure, speed metrics etc. These time-stamped data leverage monitoring processes necessary for cleaner transports. For example, formalized assignment processing within the confines of an integrated computational solution, combined with automated instant retrieval of vehicle performance data, facilitated by wireless communication ensure constantly updated sources of timely information. Each truck in a fleet is seen as a sensitized object capable of collecting and reporting high-level granularity data, making them essential enablers of eco-effective fleet management operations. However, they depend on standards-enabled information infrastructures that integrate embedded and mobile technologies with back-end enterprise IT systems. Such infrastructures rely on a "plug-and-play capability" in that they allow constituent technologies to recognize and establish working configurations with other components. This capability has the potential to tie together various social and technical elements within and across organizations in novel ways.

History

The pioneering efforts with the MSI project were initiated by Viktoria Institute back in 2002, and some 2 years later the involved actors decided to form a consortium to develop and promote an industry standard. To pursue unison at the industry level has been critical for two reasons: 1) Enable different technology vendors to learn one interface and minimizing friction between heterogeneous systems; and 2) Create information consistency across road haulage firms and leveraging inter-organizational process linkages. A team led by an action researcher and composed of technical staff at the participating firms executed the standard design process. Based on a thorough review of the proprietary interfaces of the involved firms, the team developed a standard that was revised over 7 iterations. The firms evaluated each release of the standard in light of their own proprietary interfaces and ongoing integration projects. User firms discussed suggestions for improvements with vendor representatives in project and work meetings, and some were implemented in a new prototype that was again subject to discussions. The standard was evaluated through three test cases in 2006. One year later, in 2007, the MSI Group was formally established as a commercial consortium. Two authentic integration projects were carried out in 2009, and 12 road haulage firms have implemented the MSI standard.

In the next section, I continue by giving an overview of the development of the MSI.

8.5 Development Process

The development of the standard accelerated from early 2005. The researchers realized these efforts would put the cooperative spirit within the platform initiative to test. They therefore decided to host all meetings on neutral ground. The vendors, especially those with little previous experience of cooperative development efforts, appreciated the Viktoria Institute as the physical meeting place. To spur further interactions among ecosystem members, the researchers launched a "Mobile-Stationary Online Development Forum". It generated less activity than expected, but the

discussions nevertheless led to important design decisions. During spring 2005 there were important interactions across vendors and haulers with a commitment to overcome the negative impact of proprietary interfaces. The platform initiative had grown strong enough to resist diverging pressures.

Still, the stability of the initiative was put to test when Hogia, the dominating stationary technology vendor, threatened to leave the standardization effort. During a meeting in September 2005, Hogia representatives abruptly declared they were investigating whether the current interface prototype posed an infringement of intellectual property rights related to their proprietary interface, and they called for immediate halt of any development. Hogia's behavior was surprising and threatened to derail the entire process. As development was halted, the rest of the platform members analyzed Hogia's claim and how to respond. They concluded there was no substance behind the claim. The researchers worked closely with the TRB representative to author an open letter signed by all remaining members. The letter declared the initiative's intent to go on with the standardization process and invited Hogia to a meeting to reconcile differences. Meanwhile, Hogia put pressure to have the Viktoria Institute withdraw from the standard development. Hogia had a minor share in Swedish ICT (SWICT), the research group owning Viktoria, and used this to spur debates between senior managers from both sides of the issue. Eventually, Hogia distributed a letter to the platform initiative declaring it had left the initiative, publicly denouncing legal action, and referring to a company history of a self-developed open interface and a commitment to applied research. The remaining members viewed this reply as arrogant and it galvanized their continued cooperative efforts. The TRB spokesperson's active role throughout this process had eventually made TRB the de facto industry representative.

At the time of the Hogia conflict, LBC Frakt Värmland (a member organization of TRB) had decided to invest in a more advanced digital infrastructure that would integrate embedded, mobile, and stationary components from competing vendors. The managing director as well as the IT manager, who both had attended MSI project meetings, saw the emerging standard as aligned with their decisions and they actively pushed to move the standardization process forward. Well aware of the huge interest among IT vendors to get the contract (the investment was large), LBC Frakt stated they expected the eventual vendor to guide the integration effort based on the MSI standard. As a result, the standardization effort turned into serious business. The standard was assessed and revised six times in light of proprietary

interfaces and ongoing integration projects. Three revisions were particularly important:

•To support management of working hours, initial designs included inter-system communication between fleet management monitoring services and data from vehicle sensors. However, network members found it difficult to conceptualize the required mapping and management of working hours was removed from the standard.

•Incorporating sensor data from embedded systems could give mobile and stationary vendors competitive advantages. Hence, concerns from embedded vendors resulted in a compromise to only include embedded data relevant to transport assignment. While fuel consumption was included, high-resolution data used for other purposes such as vehicle maintenance and engine development were excluded.

•A context schema was developed to support terminology that reflected firm-specific local conditions. Based on this mechanism, the MSI standard could adapt to specific business terms in any given communication. However, this triggered a discussion of who was responsible for defining and managing the schemas. In the end, it was agreed to assign this responsibility to the stationary vendors.

During the summer of 2006, IBS and Vehco tested the MSI standard in one setting (LBC Varberg) and Locus and Vehco tested it in another hauler (LBC Frakt Värmland). The researchers played an important role in designing the test through guidance on how to secure reliable and valid test results. Both assessments suggested the interface required new workflows because of changes in relationships between mobile and stationary vendors. Also, the standard implied a shift away from stationary dominance as all involved actors now had to negotiate the content and structure of critical business information. As a result, the stationary vendors understood that the MSI standard positioned their systems as part of larger infrastructures with other important components.

During the same period, the platform initiative got funding from SWICT to transform the activity into a commercial standardization consortium. MSI was a showcase that SWICT marketed as exemplar applied IT research and all network members realized the standard would soon require more sophisticated principles for development, maintenance, and diffusion. In August 2006, the MSI members presented lessons from the test cases at the largest conference event in the Swedish road haulage industry, emphasizing

how the interface standard clarified roles and relationships among IT vendors and helped specify the requirements for combining heterogeneous technologies into a coherent digital infrastructure. This led to considerable attention from trade press, road haulage firms, and IT vendors and made the shared platform initiative well known across the industry.

In late summer 2007, the platform initiative was formally transformed into a commercial standardization consortium financed via member fees. The primary task of the 'The MSI Group' was to develop, maintain, and validate the industry standard. The consortium was structured into a board of directors, a strategy team, and a technical committee. The researchers were actively involved in founding the consortium with particular focus on developing a strategy for intellectual property rights to avoid incidents similar to the one with Hogia. The reorganization meant TRB took over leadership in MSI development from the researchers. As the MSI Group stabilized and attracted new members, including Barkfors, Consafe Logistics, Cybercomgroup, and Pocketmobile, it came to represent a critical mass of the Swedish road haulage industry.

The researchers now turned their attention towards diffusion of the MSI standard. The researchers applied for funds to help the MSI Group turn the standard into a dominant design. The positive image of the MSI Group meant it was relatively easy to attract funds. VINNOVA supported the project "Network Innovation through Vertical Standards" to develop specific lessons on how collective action can lead to service innovation enabled by vertical technology standardization. Also, SWICT funded the project "Sustainable Transports" to create new knowledge on how researchers can support digital solutions for environmental sustainability.

To spread across the industry, the MSI standard had to be adopted and used by vendors and haulers to improve business processes. However, the vendors were considerably more pleased with the standard because of its focus on innovative solutions based on new industry practices. As a result, some IT vendors approached the MSI Group in spring of 2009. As an example, vendors focused on route optimization technology found the standard created a whole new world of digital opportunities because it enabled cooperation and information exchange between distinct socio-technical networks. The standard allowed these vendors to see how their solutions could become part of larger digital infrastructures and it gave them a vocabulary and thematic structure they could use in negotiations with potential partners and customers.

The MSI Group members found the standard made their lives better and easier. The shared infrastructural understanding meant that the cycle time of integration projects could be reduced without compromising quality. This was even true in situations where the MSI standard was not used. Following interactions with vendors that now promoted the standard, Hogia realized integration practice were changing. Facilitated by TRB and the researchers, they therefore returned to the shared platform initiative. This was interpreted by some as an indication of successful standard diffusion on the supply side. During the same period, two haulage fimrs, Lantmännen and LBC Frakt Värmland, decided to implement digital infrastructures based on the MSI standard. This was an important step forward given the limited attention received from road haulage firms so far.

Several vendors signaled interest in taking on the assignment at LBC Frakt. However, their offerings typically reflected use of proprietary interfaces. The managing director of LBC Frakt therefore sent a letter to the MSI Group, officially criticizing its members for undermining the standardization effort (this was depicted as 'the revolution in Värmland' in the trade press). Although LBC Frakt was disappointed with the vendors, they appreciated the MSI group had developed into an official industry forum in which these issues could be addressed. They eventually selected two vendors on the mobile side and Locus Scandinavia for the stationary part of the digital infrastructure. During the integration process, the flexibility offered by the MSI context schemas caused considerable debate. Eventually, LBC Frakt concluded the standard provided too little guidance and decided to rely on Locus' proprietary interface because it had first-hand experience with it. Still, they were determined to support the shared platform initiative and decided Locus' interface should be MSI-adapted through a project involving LBC Frakt, Locus, and TRB. The outcome was a solution for transport order management.

Informed by the LBC Frakt case, the MSI Group revised the standard to facilitate its diffusion into road haulage firms. The strategy was to modularize the standard into a set of core modules, and the LBC Frakt solution served as basis for the order module. At this point, however, the MSI Group faced considerable challenges when Hogia announced they had recruited TRB's MSI developer. Although this enhanced Hogia's innovation potential, the researchers had to once again take leadership in the MSI group. During the spring of 2010, the researchers engaged individually and through the MSI group to implement the modularization strategy. The researchers teamed up with InnovationLab. Its combined computer science and informatics expertise paired with logistics competence proved valuable in designing a resource, a route, and a quality module in addition to the order module.

The MSI Group members wanted the modules to be designed to support environmental sustainability. As the group lacked the required expertise, they engaged a PhD in environmental informatics from Chalmers University of Technology that at the time ran his own business, eco2win. In June 2010, the group initiated the development of the core modules together with DPS (vendor of route optimization technology) and Volvo. The development process took almost two years of iterative development with feedback from most MSI Group members. In late 2012, the four modules were handed over to the MSI Group. Finally, during a meeting in May 2013 the MSI Group decided to dissolve the platform initiative and its members got back the rest of their membership fees. Virtually all the actors, however, payed tribute to the shared platform initiative and they continued their search for architectural solutions and strategies consistent with the MSI standard.

9 RESEARCH DESIGN

In this section I give a brief account on my research journey. Subsequently, I describe the methodology I used to analyze the archival and primary data of my project and elaborate how the data collection was organized.

Leonardi's (2011) imbrication framework is then applied to provide a detailed analysis of not only the ways in which technology architecture shifts shape coopetitive dynamics in such settings, but also how coopetitive dynamics between actors affected the choice of the architecture.

This analysis creates the foundation for developing theoretical contributions to the platform literature by discussing the nature of the coopetitive dynamics that characterize shared platform initiatives where emerging technology architectural shifts challenge their governance strategies. In addition to these theoretical insights, my dissertation offers implications for platform leaders who seek to nurture innovation in their ecosystems.

9.1 My Research Journey

In November 2011, I started to work as a research assistant and a software developer at the University of Borås. Since then I have worked on the MSI project that ended in year 2013. During this last stage of the project, I actively participated and collected data in all workshops, meetings and interviews which gave me an opportunity to observe the network dynamics, and to contact and communicate with actors to gain better understanding of their views, motives, and even tensions between the partners. I documented all the empirical insights in observation notes and through my programming expertise; I gained useful insights into the architectural design of the platform. After completion of the MSI, I did complementary interviews with the main actors in May 2016 to carefully discuss events described in contradictory documents and the aftermath of the project.

In February 2014, I got enrolled as a Licentiate student on half pace at the University of Gothenburg and was funded by the University of Borås (since 2014, I started to work as an Adjunct Professor on half pace at the School of Library and Information Science at the University of Borås. I taught technical courses at two programs: Bachelor of Web programming and Master of Digital Libraries. I also supervised Bachelor theses during spring 2016). I presented my Licentiate draft at the Pre-Lic seminar in June 2016 and

defended my Licentiate in November 2016. After I defended my Licentiate I started my doctoral dissertation work at the University of Gothenburg under the direction of Professor Rikard Lindgren (primary advisor) and Associate Professor Ulrike Schultze (secondary advisor).

During my doctoral program, I took higher education courses at different universities. Among them was the Open Innovation course at ESADE business school in Barcelona. The course was lectured by Henry Chesbrough and Wim Vanhaverbeke and I received valuable feedback on my work. Although, Open Innovation did not last as part of my dissertation, acceptance to this course played an important initial role in my academic training. I specifically got acquaint with Technology Management field's prominant articles and conversations related to my work.

While my dissertation is in traditional monograph format, I have presented parts of my findings at both major and local conferences and workshops. I presented my progress in yearly doctoral conferences at the University of Borås and University of Gothenburg. In 2014, I presented an extended abstract as the first author together with Rikard at the OASIS pre-ICIS2014 workshop and I got useful feedback from scholars and mentors of my session Professor Cathy Urquhart and Professor Dubravka Cecez-Kecmanovic. In 2015, I together with Rikard sent an initial analysis of coopetition in the MSI project to the Journal of AIS (JAIS) Theory Development workshop that got accepted. I later presented the full-fledged analysis in a complete paper, which I wrote as the first author together with Rikard, at the Hawaii International Conference on System Sciences (HICSS) 2016. In 2017, I presented the imbrication analysis of MSI in ICIS2017 as the first author together with Rikard and Ulrike (For more details on my presentations refer to Chapter 13).

During my doctoral program, I have been invited to prominent doctoral consortia in the Information Systems and Technology Management fields (ECIS2016, OCIS2016, and ICIS2016). My session mentors at ECIS2016 were Professor Tina Blegind Jensen and Professor Jonathan Wareham. And at ICIS2016, I got helpful feedback from the students and my session's mentors: Professor M. Lynne Markus and Professor Mary Beth Watson-Manheim. I unfortunately could not participate in OCIS DC as part of AoM2016 because my visa was delayed.

In May 2016, I spent a month at Cox Business School at Southern Methodist University (SMU) to work with Ulrike. As a result of this visit, I put parts of my dissertation in three different papers to: ICIS2017 (*accepted*), Information

Systems Research (ISR) (*invited to resubmit*), and Research Policy (*under review*) as the first author together with my two advisors. Finally, I defended my dissertation draft at my trial seminar on 9th of November 2017. My opponent was Professor Ioanna Constantiou who gave me constructive and useful guidance to improve my work.

9.2 Historical Method

Lack of contextual understanding makes re-analyzing of secondary qualitative data challenging (Corti, 2007). This challenge, however, is viewed as a blessing in disguise since it gives the researcher distance from the data and results in a less biased analysis (Glas, 1963; Heaton, 2004). The other discussed advantage of re-using other researchers' data is lowering the research cost (Corti, 2007; Glas, 1963; Heaton, 2004).

Despite the encouragements, there are very few researchers in IS that use data collected by others. This scarcity can be traced to problems surrounding this method of data gathering and analysis. Methodologically, analyzing such data brings more complexity to the researcher's desk. Ethically, using such data can be challenging since human objects gave consent to use the data for a research other than the project at hand and finally credibility of such data should be carefully scrutinized.

Besides methodological and ethical problems, however, lack of norms and standards in making data available from one research to the other should not be neglected (Corti, 2007). Indeed, qualitative researchers can benefit from clear standards and frameworks to regulate re-use of data.

The data from the years I have been part in the project is not secondary but the rest of the data for this study is primarily secondary and also of historical nature dating back to more than a decade ago. This makes this data eligible for both secondary and historical analysis. These two analysis methods have many overlaps. Both have special focus on how to use and interpret data that is not gathered by the researcher.

Historical analysis, however, pays closer attention to handling a larger amount of data; how to organize, how to validate and when to stop collecting more data are center stage. Therefore, in order to be able to analyze and categorize the data seen in table 8 I used Historical Analysis (hereafter HA) framework (Mason, McKenney, & Copeland, 1997ab). Mason et al. (1997ab) have presented this framework for IS researchers inspired by historical analysis frameworks done by historians and social scientists. This framework

offers a comprehensive guideline through all steps of analysis from understanding the data to writing the narrative via the selected lens. I followed what Porra, Hirschheim, and Parks (2014) calls Interpretivist historical analysis relying on Walsham's (1995) work on interpreting qualitative material.

In what follows I give a summary of my data collection process, followed by a closer look at HA by presenting its importance and background in IS. I then go through each step HA offers to analyze historical data. For each step, I explain its nature and clarify how I have conducted it in my project. I conclude the method section with what was learned through applying Mason et al.'s (1997ab) framework and what challenges I faced.

The data collected in this project originate from numerous data sources including semi-structured interviews, board, project, and work meetings, workshops, e-mails as well as strategy and technical documents (Table 8). In addition to these main sources, I have read and analyzed numerous industry presentations, project applications, press releases, popular press articles, module and standard specifications, use case and test case descriptions, and my own observation notes.

The three most important sources of data are project meetings, work meetings, and interviews. In total, 30 project meetings were held over the twelve-year effort. Typically chaired by the researchers, the meetings helped coordinate the project and mobilize support for the research agenda. The recorded and transcribed material from these meetings provided detailed description on the group dynamic. 75 work meetings were held with member organizations. These meetings primarily concerned the technical development of standard prototypes and modules. Most of the meetings were recorded and transcribed for later data analysis. Finally, 136 formal interviews were performed, recorded, and transcribed. Respondents included technology vendors, developers, drivers, dispatchers, and haulage firm managers. The interviews lasted 80 minutes in average and covered different themes relevant to IT development and use in the road haulage setting (Table 8).

Table 8 MSI data sources

Data sources	Amount
Interviews	136 (Average: 80 min)
Project meetings	30 (Average: 240 min)
Work meetings	75 (Average: 120 min)
Workshops	18 (Average: 300 min)
Board meetings	17 (Average: 75 min)
Emails (dealt exclusively with substantive issues)	267
Presentations (Word documents, power points)	83
Project applications	9
Decision letters	5
Strategy documents (IT vendors, MSI group)	32
Technical documents (IT vendors, MSI group)	21
System demonstrations	18
Standard applications	22
Environmental reports	14
Module specifications	12
Press releases	12
Popular press articles	11

By relying on imbrication framework (Leonardi, 2011) for analyzing shared platform coopetition dynamics and architectural changes I make sense of the imbrication patterns of social and technology agencies of MSI through the years. Given this ambition, I first extracted a timeline with the main activities and events (Figure 6).
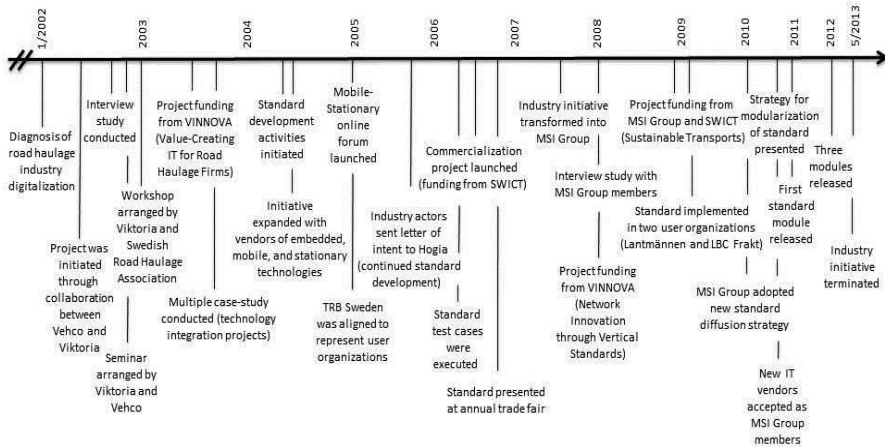
Figure 6 MSI timeline

This analysis led to the identification of three major technology architecture shifts, which serve as a baseline for the key phases that make up the narrative of my case interpretation (See timeline in Figure 7). Each phase consists of an imbrication pair showing the reciprocal effects of coopetitive dynamics and technology architecture on each other (See imbrication in Figure 8).

Before going through HA steps in my dissertation project, I present a brief background on studying history and origin of historical analysis in IS. I proceed by presenting HA steps under the *Process steps* rubric.

History is one of the cornerstones of any field. IS is not an exception therefore the study of history in the field has been emphasized in the discipline through various callings for further research to enrich the history of the field. Joseph Schumpeter, the economist and historian, suggests any field of scientific research needs to produce four kinds of knowledge to be qualified as a "discipline" : (1) empirical data, observations and facts, (2) theories and paradigms, (3) ethics, and (4) history (Mason et al. 1997a, p. 258). Study of history is necessary to make meaning of the other three knowledge forms over time. However, IS knowledge production is heavier on the first two (Orlikowski & Baroudi, 1991; Porra et al., 2014).

Scrutinizing the interplay of social and economic factors of using IT over time is an important field of research in IS. However, longitudinal studies

that look into such factors through analyzing changes over an extended period of time are needed. This scarcity of research on continuity is even more noticeable when it comes to research on aligning interests of a group of heterogeneous actors with different perceptions of reality.

IS is a somewhat young discipline. Study of history is therefore not as regulated and rich as it is in sociology, history or not even management. Disciplines with stronger historical works have their own approach and frameworks to conduct the study of history in the field, all inspired by historians' works. In IS the only established framework is the framework introduced by Mason et al. (1997ab) consisting of seven steps (Mason et al. 1997ab). Through their framework, Mason et al. (1997ab) hold IS researcher's hand through the analysis process; beginning from narrowing the researcher's focus until writing the transcript based on the pile of historical/archival data. Mason and his colleagues apply their framework on historical account on Bank of America (Mason et al., 1997ab) that gives better insights on how to use the framework.

Not so many IS researchers have followed Mason and his colleagues' footsteps. Porra, Hirschheim, and Parks (2005) are the only IS researchers that have done an historical work that is published by top journals in IS after Mason et al. (1997 ab). They used Mason et al.'s (1997ab) framework on an historical account of Texaco corporate oil company's Information Technology functions (Porra et al., 2005). They also provided a rich four layer framework including paradigm, method, approach and techniques in HA (Porra et al., 2014).

The IS community's interest is growing in understanding the historical context of IS phenomena. Studying the evolution of IS phenomenon not only helps us understand the events happened in the past that affected the IS phenomenon but it affects the future by learning failure and success parameters of previous endeavors (Mason et al. 1997a; Porra et al. 2014; McKenney et al. 1997). Deeper understanding of the IS changes is argued to help IS scholars to have a sound knowledge of the field and the field's origin and identity (Bryant, Black, Land, & Porra, 2013).

Bannister (2002), however, believes that historical works in IS are not radically different from other popular research types produced in the field. In contrast, Bryant et al. (2013) and Oinas-Kukkonen and Oinas-Kukkonen (2013) believe understanding historical methods and techniques is a valuable asset for any IS researcher to be able to interpret previous research. Indeed,

observing continuity with the right tools is of great importance in studies that evolves around scrutinizing use of technology.

Historical analysis studies (e.g., Porra et al., 2014) and longitudinal studies (e.g., Gregory, Beck, & Keil, 2013; Sun, 2013; Ranerup, 2012; Bhattacherjee & Premkumar, 2004; Venkatesh & Brown, 2001; Webster, 1998) can be perceived as very similar since they both look into events over time. But a fundamental difference is that in HA researchers let the events and data guide the study while in longitudinal studies theories set the guidelines for research design and data collection (Porra et al., 2014; Mason, 2002).

Mason et al. (1997a) were inspired by HA in other disciplines including history, sociology, and management disciplines. They coined their framework as "an historical analysis" pointing to the fact that for each step they have elaborated the ways they can be done based on interpretive guidelines. However, each step can look differently and the researcher can choose other qualitative approaches common in IS (e.g., critical or positivist (Myers 1997)). On the contrary, Porra et al. (2014) call their take on HA "The historical analysis" because they go through different paradigms (e.g., functionalism), approaches (e.g., pragmatic) and methods (e.g., case study) that are familiar to IS researchers.

9.3   Process Steps

Different disciplines approach the process of forming a narrative out of historical or archival data with different assumptions and interpretations. Consequently, historical analysis is presented in different steps across courses of studies: e.g., Scientific HA has three steps (Grigg, 1991), marketing HA has five steps (Golder, 2000), consumer HA has three steps (Smith & Lux, 1993), etc.

In IS, the qualitative method of historical research is presented in seven steps: (1) focusing questions, (2) specify the domain, (3) gather evidence, (4) critique the evidence, (5) determine patterns, (6) tell the story, and (7) write the transcript (Mason et al.,1997a). Below each step is introduced thoroughly and explained in relation to this study's empirical context.

To find patterns, I have iterated between data and theory to find the right thematic quotes for each step of the analysis. By following Historical analysis I needed three rounds of coding which I explain below. Later, while elaborating my analysis based on HA I will refer to these coding rounds again.

Before starting the analysis in the first round of analysis, I read the data that was categorized by type (e.g., funding applications, interviews, workshop presentations, etc.) and year. I coded the data to get an overall picture of the industry and the development of the project through the years. Of special interest in this stage was to understand how haulers (users) worked, how different types of IT providers worked and to get an overall picture of the project.

After this analysis round, the results were communicated with the project leader of MSI to validate the results and consult the possible inconsistencies in the timeline or events brought up in different data sources. Besides, the results of each coding round were analyzed in relationship to the literature. The first analysis round resulted in a timeline mentioned before (Figure 7).

In the second round, I specifically looked into coopetitive dynamics by looking into relationships between project partners. The result of this phase in conjunction with the understanding from round one resulted in list of coopetition relationship pairs showing the coopetitive dynamics between partners (Appendix2). This understanding helped shaping coopetition diagrams (Figures 9-11).

In the third round of analysis, I focused on architecture of the core and interface of the platform. As a result of the first round, I had an overall picture of which technologies were important to the development of MSI platform through the years. *Developer notes* documents were of great help in this process to deepen my knowledge on the architecture of MSI. The results of this round were illustrated in architecture diagrams (Figures 9-11).

After these rounds, I saw the need to do complementary interviews with some key actors to be able to have a clearer picture of the last stage of the project and the post-MIS era. In my quest for the available partners who were interested to collaborate, I managed to conduct interviews with 1) The transport and logistics manager at Volvo, 2) The (former) managing director of Vehco and 3) TRB's representative in the project who presented the customers. I went through the three previous analysis rounds for complementary interviews as well and justified the previous analysis results accordingly.

Finally, in the last analysis round, the reciprocal relationship between coopetitive dynamics and architecture shifts and also the governance decisions that guided the initiative through the changes were in focus. At this stage, the timeline was further developed by subdividing the events into three

phases, each labeled according to the architectural design underlying the emerging standard: Open Services Gateway initiative (OSGi), Web Services and Business Process Modules (Figure 7). The events of each of these phases, as well as the state of the technology and industry players before and after the MSI platform initiative were then analyzed in isolation.

For each of the three phases the platform architecture and the actions of the platform participants were analyzed in detail in order to identify both human and technological agency, as well as their interaction in each stage. Each of the three MSI development phases began with human agency, i.e., the intent to develop a new technological infrastructure for the MSI platform and ended with a new architecture as a result. The end state of each stage of the MSI platform's evolution was captured diagrammatically in terms of an architectural diagram and a coopetition map inspired by Bengtsson et al. (2010).

Using Leonardi's (2011) representation of the imbrication of human and material agency, I read the empirical data again and analyzed the relationships between the social and technological factors. After much back-and-forth between the imbrication model and the data, a stable picture of the MSI platform's evolution as a sociomaterial organization emerged (Figure 8). The analysis rounds and thematic quotes of each round are illustrated in table 9.
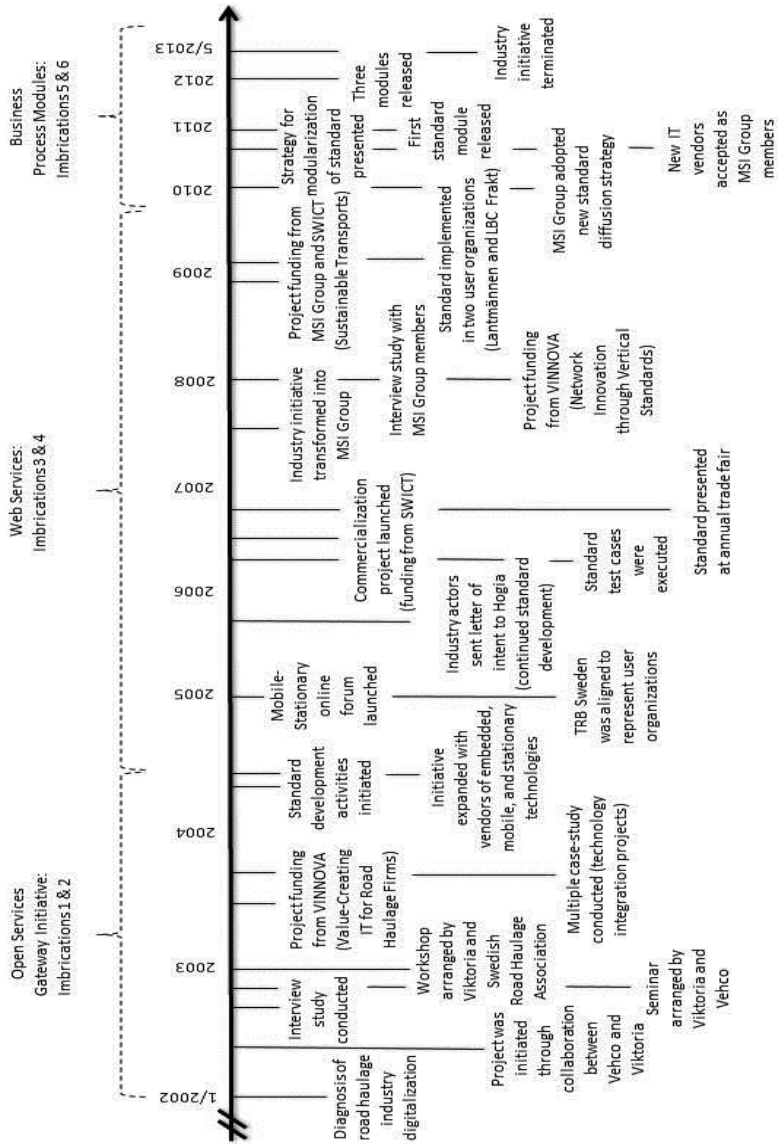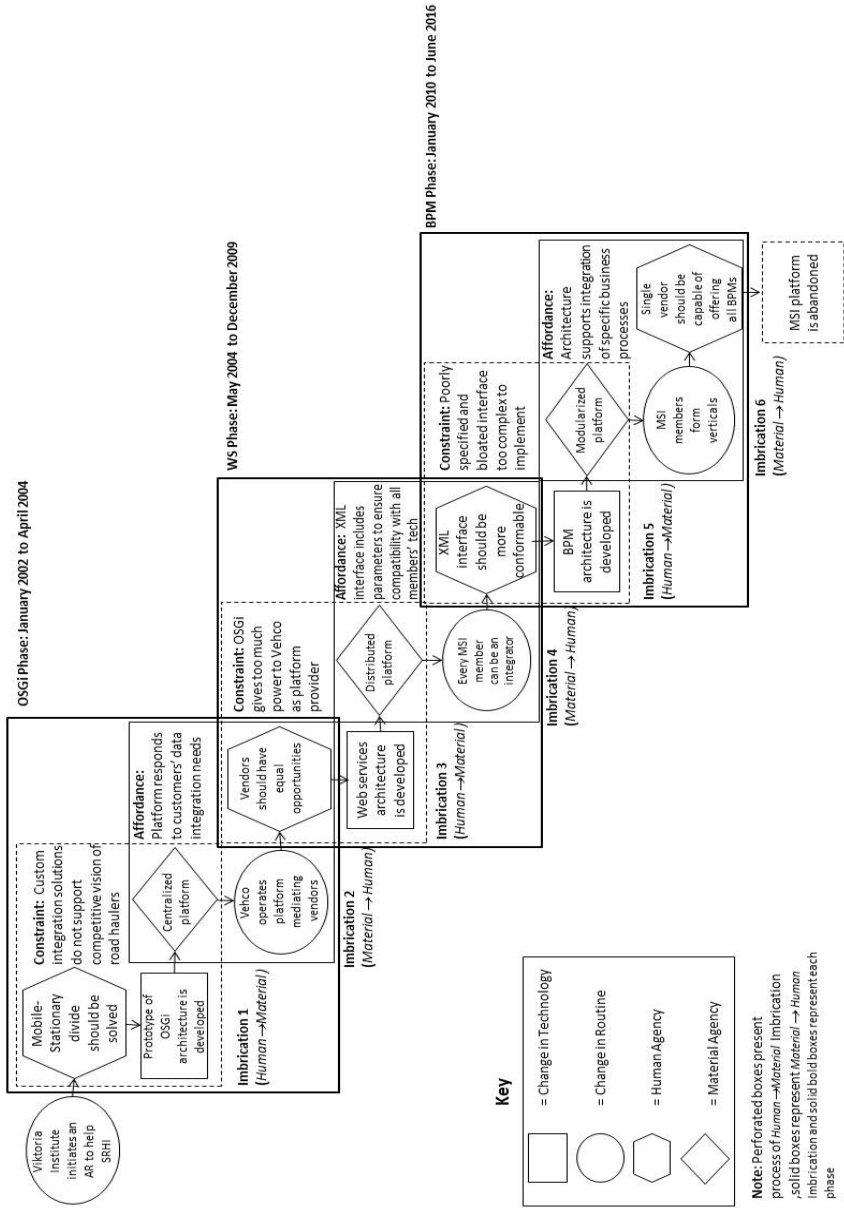
Figure 7 MSI completed timeline

77

Figure 8 MSI imbrications

Table 9 Description of the Coding Stages of my study

Coding Stage	Exemplary questions	Thematic codes	Outcomes	Exemplary quotes
Understanding how the industry functioned and how MSI changed over time	How did haulers work? What was the desired outcome for the haulers? What were the main partner types? How did partners differ across technical expertise, or industry focus? What did these different partner types wanted? How did they contributed to MSI? When did they joined and left MSI? How did the competitive position of each actor looked like?	Actor info Actor type Governance Haulers Motivation Network Timeline Technology providers Truck manufacturers Technology	Key actors Contributions of the MSI participants Actor types Haulers' workflows Timeline	**Example 1:** *"Yes [we have third-party providers] out there in Europe. There are surely 15 to 20 [actors] in Benelux that retrieve vehicle data. They are much more mature than [actors in] Sweden. (Global managing director at Volvo trucks, October 16, 2003)"* **Example2:** *"Transport leader is the most important person in a hauler given the Spartan utilities to do their job... but they get better and better tools e.g., Routelogistics, route planning. We have transport planning, we have Codriver that gives a picture of how the whole fleet looks like every given second, etc. It improves but it is still a complicated job to sew together all these systems that go into a hauler... I don't think it is going to get completely automated.(Managing director at Vehco, October 3, 2004)"* **Example3:** *"haulage companies did not have IT managers; they had a guy who ordered the toners for the printer and installed office programs and that guy, often a guy was then promoted to IT manager but there was a wide gap between procurement skills and the main knowledge." (TRB representative at MSI, April 13, 2016)*
Understanding the technologies that were used in the development of MSI	What technologies were proposed? Which MSI partners contributed to the development of the technology? What characteristics the technology had? What were the advantages and disadvantages? Why was it changed?	OSGi-Interface OSGi-Core OSGi-Periphery WS-Interface WS-Core WS-Periphery BPM-Interface BPM-Core BPM-Periphery	The main technologies used and the reason for changes. A segmentation of the material in to three phases based on the technology used.	**Example1:** *"Very early in the development work we saw that OSGi was the only way to ensure remote-control of updating and maintenance of the service content... OSGi is also a framework that facilitates interoperability...."(Grant application by Vehco and Viktoria, August 17, 2002)* **Example2:** *"We want to be able to integrate irrespective of provider of different systems [to do so] we are talking a lot about WebServices... it's a technology that would solve the problem if every actor use it as I've understood it from our technical staff... that's a step further than Pharos mobile XML". (Managing director at Vehco, October 3, 2004)* **Example3:** *"MSI presently consists of a generic schema, a more adaptive context schema and a transmission agreement (HTTPS and SOAP)...The generic XML schema holds a number of core objects. Attributes in these objects can be specified in a contextual schema, unique for each context. This will allow a limited adaptability whilst retaining the structure, thus aiding the interpretation necessary in ad hoc integration." (MSI Development Notes version 0.18, May 15, 2006)*

| Understanding the coopetitive dynamics between MSI partners | Who were the participants of each workshop? Which partners worked closer to eachother? Which partners collaborated with each other in the industry? Which partners' products and services were closer to each other? Which partners shared/did not share information? | Cooperation Competition Coopetition Trust Complementarity Tie Strength Symmetry Intensity Hostility | A schematic of coopetitive dynamics of MSI partners and a table of coopetitive dynamics according to actor types. | **Example1:** *"The truckmanufacturers' systems [is brand specific and] do not get applied on eachothers' vehicles... The rivalry between these two companies is still high because they want to produce the best truck". (Competition analysis document, 2002)* **Example 2:** *"We actually welcome sharing our expertise openly. It's likely it would lead to potentially more business negotiations for us and I expect us to win them all in the end. We've learned it takes a lot of time and resources to develop an effective optimization engine, so I guess others understand they're well behind us... We're therefore not afraid competition would intensify in that way." (managing director at DPS, 2012)* **Example3:** *"...but they [the hardware at the time,] were not flexible enough [at the time]... Very few telematics actors actually recognized the need for simplicity... then come companies like Velico who recognized that the driver need to be able to press a button with their thumb. That's the only thing that they can do so they were pioneers in that sense." (TRB representative at MSI, April 13, 2016)* |

In what follows, I explain my analysis in detail based on HA steps presented by Mason et al. (1997a).

9.3.1 Focusing questions

The researcher should initiate the analysis by having some general questions in mind before approaching the data (Mason et al., 1997a). The general assumption at this phase of the history writing is that "material must precede the thesis" (Tuchman, 1981, p. 9). This step is for historians to shape open-ended questions (Oinas-Kukkonen & Oinas-Kukkonen 2013) before going forward. At this stage, the questions can be vague and serve as a simple guidance. This step has been known to take a long time to accomplish (Mason et al., 1997a; Mason et al., 1997b; Porra et al., 2005; Porra et al., 2014) mainly because the historians need to approach the "never-ending" evidence to some extent to be able to reach the questions.

For this study, I approached the material to simply fathom the network dynamics and how the Swedish road haulage industry had changed over the course of the MSI project. My involvement in the last phase of the MSI project was helpful in this step. By using Leximancer, I developed an initial theme analysis to understand dominating themes in the data. I described my initial understanding of the material in an extended abstract titled "Technology Standardization for Transport Efficiency: On the Greening of Frames". I wrote the extended abstract as the first author together with Rikard which was accepted and presented at the OASIS pre-ICIS 2014 workshop.

As the result of the process explained above my overarching question became: "How do the participants' coopetitive behavior and the platform's technology architecture reciprocally shape the evolution of a shared platform?"

9.3.2 Specify the domain

The questions produced in previous step determine the domain for inquiry and dictates several methodological presupposition (Mason et al., 1997a, p. 312). The domain in this study is the shared platform. I analyze the network of actors that are part of designing the platform, the architecture of the platform and the connections between these two. To be able to design the core and standardized interface of the platform, a varied heterogeneous group of actors were invited to this initiative resulting in dynamic relationships in the group.

Historically, Swedish road haulage firms did their work by help of pen and paper; their workflow spanned from getting an order, dedicating the task to a driver, determining the most appropriate route to delivering the goods. By the beginning of the millennium, software vendors and truck manufacturers initiated projects on digitalizing the process. They managed to digitalize some part of the workflow but the result was fragmented in general. There were important problems inhibiting the digitalization work: firstly, there existed various software for different parts of the workflow (e.g., order handling to handle orders or route optimization to find the viable route) but these software were not integrated with each other, so haulers had to do the data converting from and to different software manually which given the low IT competence these companies had was not a hurdle to ignore. Secondly, in addition to the problem mentioned earlier, multiple software options were available for each part (e.g., there were three main software vendors offering order handling software package at 2003). Consequently, haulers would end up with different customers demanding different software for performing the same task.

The ultimate problem was that truck manufacturers produced digital platforms that worked only for their truck brand which made transport management more complicated for haulers. The MSI project provided the industry with an arena where these different actors could gather and help to develop a standard. This data exchange standard would make it possible for different platforms to communicate with each other and integrate. Finally, the result of the effort would provide haulers with a comprehensive system for the first time in the history of the industry.

The preamble above makes it clear that to study the cooperation between competitors (i.e., coopetition), having the network as the main domain was necessary.

9.3.3 Gather evidence

Timeline is a typical technique historians use to organize evidence by dividing the storyline into relevant time periods and name them (Marwick, 2001). In interpretivist IS histories, evidence gathering processes ascribe to a social relativist perspective, which suggests that evidence is considered to be an interpretation of the events by the authors of the documents (Porra et al., 2014). Among all data sources, Interpretivism considers interviews to be the most important source of understanding the actors' interpretations of actions and events that have taken place (Walsham, 1995).

In the MSI project, the data was mostly categorized by the type of the documents, e.g., fund applications, project meetings, technical meetings, interviews, etc. However, to be able to extract the timeline of important events, I needed to categorize the data into years. The challenge I faced in this step was that many of the interviews, observations and even meeting notes did not have enough introductory information including the date. Therefore, I wrote a C#.Net application which went through all the files and categorized them by the creation date and language of the files in different folders. I took the language into consideration to separate Swedish and English material for each year to be able to feed thematic software with my material (Such software, e.g., Leximancer are language sensitive).

By use of Atlas.ti, I coded the material to delve deeper into the data to understand how the haulers' ecosystem and work processes functioned before and during MSI project. I coded the material to understand the competition situation in the network and to understand the different actor types. At this stage, I was particularly interested in different events that had affected the MSI project. I also was interested in the name of actors and more info on their companies. To complement the material for some of the actors, I searched for the information on the company online. The result is presented in the timeline in figure 6 and table 9 shows the coding process in more detail.

To make sure I get a correct picture of each actor involved, I looked up news related to each company for the period of time the company was involved in the MSI project. Where applicable I collected technical information on the company's product. When it came to the technologies used in developing MSI platform I looked for scholarly papers, official documentations and presentations of the technology during the years the technology was used in MSI, e.g., I collected all articles on OSGi between 2002 and 2005 (I included 2005 because it takes time for studies to get published after the study is conducted) I vetted out the 20 most cited papers among them I chose those that were helpful to complement my understanding of the use of OSGi in the MSI. I then grouped them in a hermeneutic unit in Atlas.ti software and coded them. For each technology, I also looked up code examples online and read technical forums like Stackoverflow when needed.

9.3.4 Critique the evidence

The gathered evidence needs to be critiqued and evaluated in this step.

"Some will be false, some contradictory, much irrelevant, and most of it will be incomplete. Given questionable or untested evidence, several analytical processes can be called into play" (Mason et al., 1997a).

Historians examine different sources and make conscious decisions on which material to use (Howell & Prevenier, 2001). These decisions are heavily influenced by the reliability of the material. If a combination of the various sources, e.g., oral history, and archival material reflect the same story the reliability increases (Oinas-Kukkonen & Oinas-Kukkonen, 2013). According to McKenney et al. (1997), contradictory evidence includes conflicting dates of events; changing times for hardware upgrades; differing volume figures, non-matching recollections of members in attendance at meetings; and different cost figures. It is important that the facts make the final judgements of credibility, not the theory.

After categorizing the data into years, I consulted with the MSI project manager to examine credibility of the sources. During this process a problem with interview transcription file dates surfaced. Some interviews had been transcribed a year after the actual date of interviews; therefore, their file creation dates did not match the year of occurrence. I changed the timeline and file categorizations accordingly.

Furthermore, I went through each document specifying who had produced the document (e.g., who had conducted the interview), which date was it collected and for which purpose. Next, I extracted events that did not agree with each other going through different documents and taking the events that most documents agree into account. I updated the timeline accordingly.

Collected evidence in its unprocessed state is of little value but gains its meaning when historians interpret it for their narratives (Munslow, 1997). A history is a written explanation of the perceived relationship between different fragments of evidence that the historian puts together to organize the story (Mason et al., 1997b; Porra et al., 2014). Munslow (1997) presents this stage as:

"The inference of meaning emerges as I organize, configure and employ data. It does not, I would argue, just turn up or suggest itself as the only or most likely conclusion to draw" (p. 8).

9.3.5 Determine patterns

I found coopetition dynamics interesting and important in the MSI project. An initial analysis of coopetition in the MSI project was illustrated in a paper

titled "The Tension between Stabilized Cooperation and Intensified Competition: Greening of Technological Frames in Practice" that I wrote as the first author together with Rikard Lindgren and was accepted and presented at the Journal of AIS (JAIS) Theory Development Pre-ICIS 2015 Workshop. I later presented the full-fledged analysis in a paper that I wrote as the first author together with Rikard Lindgren under the same title. The paper was accepted and presented at the Hawaii International Conference on System Sciences (HICSS) 2016.

While conducting the analysis for the HICSS study, I realized cooperation dynamics between competitors had been heavily affected by the changes in technological architectures through the years that, consequently, impacted the standard. As a result, I divided the project into three phases reflecting the three main architectural changes (Figure 7). In the first phase, the prominent technology that actors initially agreed on to base the shared platform architecture on is the OSGi. OSGi was the latest technology at the time which had attracted attention among logistic actors as a technology that made integration processes possible. The second phase is the Web Services phase; this technology became the core technology architecture for the shared platform together with the XML data type, and the last phase is about modularization. Next, I went through each phase and focus on relationships between actors and thrived to analyze, investigate and explain them through coopetition as the lens (Appendix 2) and the effects technology architecture had on coopetitive dynamics.

As stated earlier, Gawer conceptualizes a platform as an organization or a meta-organization consisting of two aspects of architecture, and value creation network (Gawer, 2014). In each phase, I used her framework as a lens to present and analyze the MSI shared platform through the two concepts Gawer (2014) represents. I found coopetition a helpful lens for looking into network dynamics.

I presented my analysis in three dissertation proposals that were accepted to 1) European Conference on Informaiton Systems (ECIS) 2016 Doctoral Consortium, 2) Organizational Communication and Information Systems/ a division of Academy of Management (OCIS) 2016 Doctoral Consortium, and 3) International Conference on Information Systems (ICIS) 2016 Doctoral Consortium.

Given the imbrication lens (Leonardi, 2011) I have chosen for my study because of the sociomaterial focus of my analysis, for each phase explained above I categorized the human to material and material to human data and

story separately. For each technology, I particularly looked into how coopetitive dynamics affect the technology and vice a versa. The coding process for recognizing these patterns is explained in table 9.

9.3.6 Tell the story

An interesting narrative supported by evidence should be provided in this stage. Histories include reverse history: creating narratives about the past by backtracking from the present circumstances (Bryant et al., 2013; Porra et al., 2014). This narrative should be presented in an interesting way without jeopardizing the integrity and consistency of the evidence (Mason et al., 1997b).

The historian should explain the changes she is studying by putting the evidence into narrative form resulting into "thick descriptions" of set of events. IS interpretivists borrow the "thick description" concept from anthropology to describe organizational changes into details to be able to make complex concepts and dynamics understandable (Walsham, 1995). Historical narratives are well structured and can have three causal levels (Smith & Lux, 1993). At the first level of the story are deep structural causes, which present the continuity factor. In the MSI project these types of causes included the start of changing mindset between vendors through integration processes, rise of tech industry, the enormous success of a start-up mostly because of focusing on haulers' needs instead of focusing on truck manufacturers' needs, the invention of OSGi, and the invention of Web Services and XML. The second level of contextual causes focuses specifically on the temporal relationship to the event being investigated (Bloch, 1953). In the MSI project, these types of causes included IT strategic decisions, annual standard meetings, and activity reports. The third level or triggering causes are unique to each phase (Porra et al., 2014). In the MSI, One of the strongest stationary software providers leaving, letting a new comer taking over the initiative was triggering events, or changes of the technology.

9.3.7 Write the transcript

While composing the story, I realized that information regarding some events was not clear or missing. Researchers that were part of the project were not sure about the answers. Therefore, I conducted complementary interviews with some of the key actors that had been part of the MSI initiative through all these twelve years. I particularly searched for deeper understanding of the events and motives that were vague and not documented earlier. In the selection process of interviewees, I tried to pick a balanced group of actors. I

chose one of the interviewees from the customer side of the platform, one from the software provider and one from truck manufacturer category. These interviews were semi-constructed interviews; I posed questions about the events I needed more information of, the after math of the MSI, and how the MSI has helped the actors in their projects today. Also, I let them to talk about their views and ideas of the project, other events they wanted to focus on, or to express their views on what they perceived as successes or failures of the MSI and finally on how such shared platform initiative would have happened today. In general, I tried to keep a "balance between excessive passivity and over direction" (Walsham, 1995, p. 78) while interviewing.

Complementary interviews were transcribed, shortly after, and further corrected by me. Later the interviews were sent to the MSI project manager for an ultimate validation to get feedback if there are conflicting views on the timeline or events presented by the interviewee.

I approached my project in a double hermeneutics form inspired by Porra et al.'s work (2005); that is, I treated the meanings actors assigned to their past with the understanding that these meanings were already interpretations of the actual happenings. While writing the story, I also interpreted the evidence based on my understanding and readings. However, where applicable, I used primary sources to strengthen the reliability of interviews, meeting notes or emails (e.g., funding application).

> "A transcript is literally something reduced to writing but for an historian it has a broader meaning as well: it is the placing of the historian's written words in the schema of those which were written before." (Mason et al., 1997b, p. 317).

After putting together the story of each phase, I put the pieces together and looked into the relationship between each phase analyzing the patterns. I put a historical context of the project (presented as Research Setting) to describe the industry before the MSI started. This background was provided to help reader to understand the complexity of the problem the MSI thrived to solve. Finally, I added quotes from the data to support the story where needed.

While writing and interpreting the material, I tried to take the outside observer role other than involved researcher. However, I agree with Walsham (1995) that neither of these roles (i.e., observer or involved) result in pure objective results since researcher's subjectivity affects different stages of the study. I have not been totally unbiased through the process. First, I have followed the data through angles that I have been interested to explore.

Second, I have had my interpretations of the project both because of my involvement and because of my perceptions of events. Moreover, my education and work experiences motivated me to scrutinize technological aspects, which meant that technological shifts became a significant aspect of my research.

I put together the final analysis in a journal paper that I wrote as the first author together with Rikard (2nd author) and Ulrike (3rd author). This journal paper is invited to resubmit to the Information System Research (ISR) journal.

9.4   Methodological Reflections

Mason et al.'s (1997b) historical analysis framework is proposed in a sequential form. However, as Porra et al. (2014) have briefly pointed out, it is more iterative and complicated than presented. The knowledge gained in each step caused me to go back to redo previous steps or revisit the assumptions made before. This problem stemmed from the lack of contextual knowledge I suffered from in dealing with the secondary data which Heaton (2008, p. 40) calls "problem of not having been there". Therefore, I believe a researcher should not completely distance herself from actors involved in collecting the primary data for the sake of objectivity. Such contacts helped me to understand the material properly. The challenge, however, for me was that many of the actors were not reachable or uninterested to help. Indeed, remembering the events as they unfolded many years ago was not easy for those people I managed to talk to.

Another challenge I faced was that the documentation of research material did not follow a proper guideline and different researchers had followed different methods to archive. The richer the data collected by researchers, the easier it was for me to re-analyze the qualitative data. More illustrative data archiving methods in collecting qualitative data, e.g., illustrative interview methods presented by Schultze and Avital (2010) had been of huge help. Because in some cases interviewees talked about a diagram or system demonstration document they were showing that was not attached to either the voice file or the transcript.

The problem of "data fit" discussed in secondary analysis (Heaton, 2004); that is when the data is not enough or appropriate for the theory lens remained. Although, HA specifically focuses on guiding the process with data. I initially chose open innovation as the theory lens, but after 6 months realized that it did not match my data. This problem was heavily connected to

the lack of contextual understanding that can misguide the researcher to the "wrong" theory lens. Therefore, more illustrative data, availability of different sources for the same events, and more available actors and researchers to contact could have helped to prevent me from wasting a long time on the "data fit" problem.

10 EMPIRICAL FINDINGS

In this section, I apply the imbrication lens (Leonardi, 2011) framework to provide a detailed analysis of the reported shared platform initiative within the Swedish road haulage industry. The analysis is structured into three major technology architecture shifts that serve as a baseline for the key phases that make up the narrative of my case interpretation. Each phase consists of an imbrication pair. For each of these imbrication moments, I identify how the material and human agencies reciprocally shaped the platform's technological architecture and coopetitive dynamics. For each phase I have determined the coopetitive dynamics between key actors of each actor type.

10.1 Open Service Gateway initiative (OSGi) Phase: January 2002 to April 2004

Imbrication #1: Human → Material

Back in the early 2000s, Swedish road haulage firms, most of whom were small to medium-sized players that specialized in the material they hauled (e.g., tree trunks, liquids), were faced with increasing competition from international logistics providers (e.g., Schenker, DHL). The haulers believed that the digitalization of their business processes would help them improve their efficiency and effectiveness.

> The haulers see information technology as one of the opportunities in helping them to improve against other [international] actors. Since we are strong in IT in Sweden, if we use this strength the costs decreases by becoming more effective (Managing director of Vehco, September 6, 2004).

However, they faced two key hurdles: their lack of technological expertise and a fragmented IT infrastructure, which consisted of a number of best-in-class systems that had been implemented as isolated solutions over the years.

In order to digitalize their operations, the road haulers needed to integrate their systems. Something as simple as calculating the cost of a delivery had to be done manually by downloading and matching data from stationary, mobile and embedded systems. Many road haulers had therefore begun investing in custom integration solutions, which were developed and maintained by the

vendor tapped to provide this service. These interfaces were fragile and unstable, as changes in one technology partner's systems could disrupt the data flow.

Overall, as small, technologically-unsophisticated players, the road haulers felt they were at the mercy of powerful actors like truck manufacturers, who frequently made changes to their embedded systems, thus forcing changes in the integration solutions, in which the road haulers had invested.

The discontent many road haulers felt towards the truck manufacturers contributed to the fragmentation of their technological infrastructure, as they sought out niche IT vendors more willing to work with them:

> "The technology vendors can be categorized into two groups. The big players are the truck manufacturers… they've dominated so far. Then we have small niche firms that utilize emerging technologies to develop novel solutions. Road haulers are suspicious of the truck manufacturers due to their brand-specific thinking so they find the smaller vendors to be a bit more flexible… these vendors do what it takes to convince the haulers to implement their specific products." (Managing director of Vehco, April 26, 2002)

Into this fractious market stepped Vehco, a university-sponsored start-up in embedded IT that positioned itself as a provider of technology services that helped road haulers improve their competitiveness and develop environmentally sustainable business practices. Having just completed a study of haulers' IT requirements and the competitive landscape of the IT vendors serving the industry, Vehco had developed a prototype, called EcoHauler, that integrated data from stationary, mobile and embedded systems. This prototype was the result of three months of thesis work by a student at Vehco. Even though the prototype simulated order data from stationary software the vision was to develop a full-fledged solution that integrated all three islands of technology:

> "Since Vehco does not work with order-handling system, the goal is that the solution gets connected to commercial systems that exist on the market, e.g., Hogia's transport planning system… The PDA in the truck is used for handling orders, and at the same time to save the [embedded] parameters for automatic cost-tracking, e.g., fuel consumption." (Managing director of Vehco, September 6, 2004)

EcoHauler generated not only reports that calculated per-delivery costs, but also provided a calculation of emissions per delivery. In order to get embedded data from the truck, telematics service providers like Vehco had two options: rely on the Fleet Management System (FMS) standard to access the parameters that the truck manufacturers' telematics applications made available, or derive data by reverse engineering the truck's CAN-bus. Vehco, like other telematics firms (e.g., Transics), opted for the latter because the data provided through the FMS standard was very limited and not frequently updated, thus constraining the telematics vendors' ability to innovate:

> "We looked into FMS very early [when it was released] in all brands: Iveco, Mercedes, Scania, and Volvo. But we got concerned about the errors it had especially in displaying fuel consumption... [Now] we have collaboration with Drivec… [a company that] takes the data directly from the CAN-BUS." (Managing director at Transics, March 10, 2004)

The truck manufacturers voiced their opposition to this integration practice, highlighting that it compromised the integrity – and thus the safety – of the vehicle:

> "What [Vehco] did was actually bad installations… they were piggybacking on the CAN. It made the CAN network function improperly and in some cases this even caused accidents. We didn't see this as a major problem, but still you don't want someone else to play with the nerves in your heart." (Global telematics manager at Volvo Trucks, April 25, 2016)

Even though Volvo Trucks regarded Vehco's EcoHauler prototype as a warranty infringement, it did not pursue legal action. Given Vehco's start-up status and its commitment to helping the small road haulers in Sweden to increase their efficiency, effectiveness and environmental sustainability with IT, a law suit would have been bad for the truck manufacturers' public image and customer relations. Nevertheless, the hostility between the telematics

providers and the truck manufacturers was palpable, especially as truck manufacturers were developing their own telematics offering.

In early 2002, Vehco approached the Viktoria Institute to initiate a research collaboration aimed at resolving the Swedish road haulage industry's technology integration challenges. By teaming up with Viktoria's Telematics Group, which had long-standing ties with transport companies, Vehco hoped to realize its agenda of revolutionizing the industry by developing a digital infrastructure that facilitated inter-technology and inter-firm integration. In May 2002, Vehco and the Telematics Group instigated the MSI platform initiative. Recognizing that they needed participation from key players in the road haulage industry (especially truck manufacturers, software providers, and road haulers), its project leaders decided to present Vehco's prototype, EcoHauler, to industry players in an effort to make the MSI project's objectives more tangible.

The two seminars (held in Fall 2002) in which EcoHauler was presented, generated interest among the members of the Swedish Road Haulage Association (SRHA). This translated into a commitment to support the MSI initiative. For the IT vendors who supplied the industry with various solutions, the seminars provided insight into the road haulers' struggles with IT integration and the business challenges this created, e.g., difficulties with inter-hauler cooperation on transport assignments. The seminars further signaled that the industry's IT landscape would shift significantly if Vehco's vision of an integration platform were to be realized. Specifically, each vendor – irrespective of their domain expertise in mobile, stationary or embedded technologies -- would have the opportunity to offer integration services, thus increasing the competition among players who had previously seen each other as complementors.

In anticipation of this probable future, many of the IT vendors signed up to collaborate on the development of the MSI platform, partly to ensure the compatibility of their own solutions with the evolving platform, and partly to remain apprised of – and possibly affect – shifts in the competitive landscape. By Summer 2003, about a dozen industry players were members of the MSI initiative. Besides Viktoria Institute, Vehco, third parties (e.g., Gatespace), and a number of road haulers, the founding members of the shared platform initiative were software vendors Hogia, Prolog, Transics, and NL Partner, as well as the truck manufacturers Scania and Volvo Trucks.

Initially, the researchers analyzed available IT solutions and core vendor competencies in detail. Interviews and other data sources from this period of

time showed that systems providing IT support to Swedish road haulage industry can be categorized in three sections: embedded, mobile, and stationary. The analysis documents from the varied range of available software at the time showed that the vendors were very much technology-focused and promoted their solutions relative to competitors rather than placing hauler requirements and added value to customers in the center of their business mantra. It was therefore difficult for small haulers to identify gaps and overlaps between different solutions, effectively hampering attempts to combine solutions.

The other prominent problem was lock-in effects; that is, many providers tried to lock their customers to buy only their products with various policies, e.g., Truck manufacturers offered only brand-specific solutions. On one hand, fleets with vehicles from multiple manufacturers were common and integrating different embedded and mobile components with the stationary systems was prohibitively expensive for small firms.

> "Contractors of haulers develop their own tailor-made solutions and try to act as system integrators. They utilize development resources, software, and hardware in a completely ad hoc fashion to accomplish these proprietary solutions." (A transport and logistics manager at Volvo Trucks, October 16, 2003)

On the other hand, although vendors were confined within their own technological paradigm and unable to comprehend wider design challenges, they actively promoted their solutions outside their core competence to increase market shares. This led to a persistent problem within the Swedish road haulage industry with failed IT implementation projects as haulers attempted to implement services offered by embedded, mobile, and stationary technology vendors in parallel.

Based on this initial understanding of the socio-technical factors that contributed to the mobile-stationary divide in road haulage firms, the MSI project concluded that IT vendors and haulage firms should meet to discuss industry concerns. This resulted in two seminars organized by the SRHA, Vehco, and the Viktoria Institute during fall 2002 to discuss insights from the researchers' interactions with IT vendors and road haulage firms. The seminars were relatively well attended, but it did not trigger collaboration initiatives. In addition, some vendors saw it as an opportunity to promote existing proprietary integration solutions to road haulers and thereby make sure the resulting platform technology was compatible with their installed

base. Given the prevailing mindset among vendors, it proved difficult to establish a coopetitive spirit among them.

> "Vendor representatives have to avoid selling their stuff at these occasions. In our discussion group Volvo did that… I experienced that Hogia, IBS, and myself didn't. From other groups I heard that Transware did, but Scania didn't. As moderators you need to find ways to get rid of such unwanted behavior. When I discuss functionality I should do it without tying specific features to the participating vendors." (Sales manager of Locus Scandinavia, November 28, 2002)

At the time, Gatespace Telematics, a telematics solutions vendor, was promoting OSGi (Open Service Gateway initiative) as an open architecture that afforded integration of road hauler's systems. It was therefore eager to participate in the MSI project. At the time, Gatespace Telematics was collaborating with Volvo Trucks to develop a solution that used CAN bus data to analyze driver work time. The OSGi architecture allowed software vendors to deploy a large array of wide-area-network services by providing a framework to integrate the disparate devices that made up embedded, mobile, and stationary systems. This made it a suitable option to respond to the haulers' integration needs. Additionally, because OSGi had already been used to develop some shared platform initiatives in the telematics domain, and specifically in Volvo Trucks, the MSI project leaders decided to adopt this architecture for the development of its shared platform.

Imbrication #2: Material → Human

OSGi's framework ran on top of a Java virtual machine and it offered a shared execution environment that installed, updated, and uninstalled applications (aka "bundles"). For software vendors to share information with each other they needed such bundles to request the data from a sending service. The OSGi server provided an interface for each such service (i.e., a piece of code that offered a template of variables and functions that the service was supposed to have). It also registered the service that a bundle had requested.
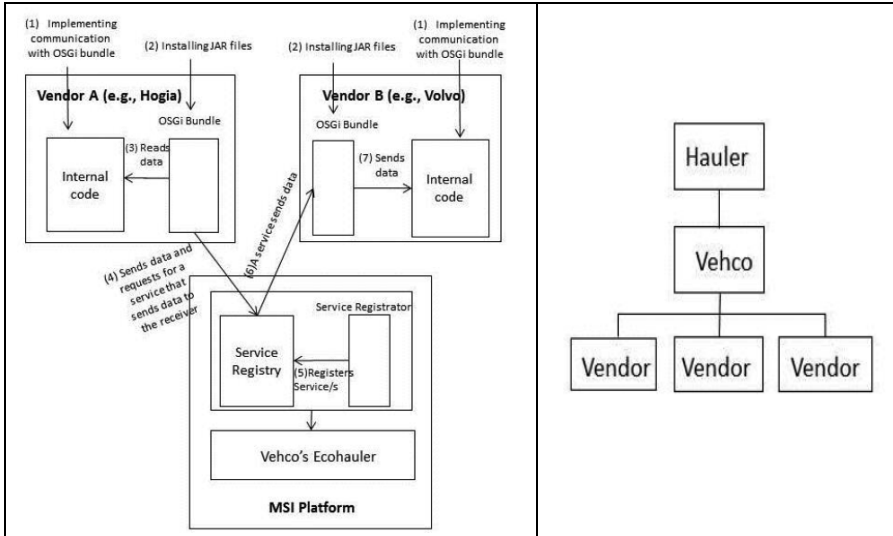
Figure 9 OSGi: (a) Technological architecture (left) and

(b) MSI network structure (right)

The OSGi architecture accomplished data integration as follows (Figure 9a):

(1) Vendors implemented the data exchange between their system's internal code and the OSGi bundle. (2) They loaded and installed the JAR file that included the OSGi bundles. (3) OSGi bundle in the sender system reads the data it needed out of the vendor's system by help of a global data structure and (4) sent the data to the OSGi server requesting a service to send the data. (5) Service registrar at OSGi server registered the service to send the data. (6) The service sent the data to the receiver. (7) OSGi bundle at the receiver sent the data to the receiver's system via a global data structure.

The interdependencies in OSGi, made for high synergistic specificity between the platform core and the extensions (i.e., IT vendors' systems). This created a situation of high coupling between the core and the extensions, which meant that the IT vendors would have to adapt their systems to meet the specific requirements of the OSGi bundles, thus limiting their systems' reusability in other integration efforts. The implementation of the JAR file on the various vendors' technological infrastructures also raised security concerns, as the OSGi server would be able to remotely access and update this client-side file.

The initial idea of a technology architecture capable of alleviating communication problems between IT systems (originating from different software vendors) was shaped by the emergence of "OSGi". Whereas the shared platform initiative explored this architectural approach for almost two years, it was originally suggested by Vehco as a way to tie heterogeneous technology components together in a coherent way. The value proposition sought for thus concerned 'compatibility' between technology vendors' different solutions.

Despite that several actors recognized OSGi to be an interesting option, Volvo was reluctant to pursue this architectural strategy when engaging in technology standard development. It had previously collaborated with Gatespace Telematics (a member of the OSGi alliance) and believed OSGi required too close access to its embedded computing resources (i.e., CAN-BUS data). Volvo thus rejected the architectural strategy proposed by other members of the platform initiative. The truck manufacturer instead preferred an architectural approach to technology standard development that could serve as a layer over its own embedded components with minimum information access needed. One of the reasons was security because Volvo perceived a huge risk that OSGi would make it possible for alien technology components to access vehicle specific parameters and possibly even change them.

> "Vehco will never get into that OSGi from an OEM perspective… simply because then they've to become a tier one supplier. It's still Volvo that has the responsibility for completing the service solution and they're just a software company." (Global telematics manager of Volvo Trucks, April 25, 2016)

Vendors thus worried that the OSGi architecture would compromise the integrity of their IT infrastructure and make their systems and data vulnerable to manipulations by the OSGi server. On the other hand, client side OSGi bundles were specific to the vendor infrastructure on which they were installed. The data and functions in these bundles were not standardized and there was virtually no guidance on how to implement the client-side bundles. This made for low interface conformability. The tight core-extension coupling and low interface conformability made OSGi a poor fit for a shared platform.

Given the complexity of the OSGi architecture and the desire to present the road haulers with a consistent and robust user experience, it was envisaged

that the MSI platform would be centrally run and managed. Vehco was chosen as the platform provider because it was seen as having the most credibility with the road haulers, due to its development of EcoHauler, which had triggered the MSI project.

As the MSI members contemplated an OSGi based architecture, they became increasingly uneasy. A centralized platform managed by one vendor, namely Vehco, meant that the customer-supplier relationships of all IT vendors whose systems were being integrated, would be mediated (Figure 9b). The proposed platform architecture thus threatened their market position in two ways: as the platform provider, Vehco had the customer's ear and was likely to become the preferred vendor, and as a result of its centrality, would be able to exert control over the other vendors, foisting its architectural decisions onto them. These apparent constraints imposed on the vendors' strategic options, increased the hostility the mediated vendors expressed towards Vehco.

In addition, it became clear that OSGi was ill-suited for the development of an industry platform with heterogeneous actors, largely due to its complex approach to data access management:

> "You need so much control of the OSGi architectural solution. Standardizing things in ways that everybody can understand is doable for sure, but implementing OSGi across all these suppliers of technology you know would be like mission impossible… the data access aspect is so complex to manage." (Managing Director of Vehco during this phase, July 1, 2016)

Even though the OSGi architecture was abandoned as a solution for the MSI platform, the members of the initiative nevertheless continued to work towards their vision of an industry integration infrastructure. At a minimum, the collaborative efforts thus far had established the haulers' problems as real and as worth solving.

10.2 Web Services (WS) Phase: May 2004 to December 2009

Imbrication #3: Human → Material
The fragmentation of IT support for road haulage firms was a result of institutionalized vendor behavior. Most of them were reluctant to share and rethink their business strategy and that undermined their ability to participate

in some form of collective action. In that situation, it was impossible to initiate cooperation between competing vendors that promoted different and in many respects incompatible IT solutions. A critical next step was therefore to expand the platform initiative to start changing the relationships and structures that kept different technology vendors apart. Over a period of six months, in quest for the appropriate architecture structure, the MSI project focused on this challenge through explorations with IT vendors, road haulage firms, and truck manufacturers. In 2004, a group of dominating industry players was in place. Besides Viktoria Institute and Vehco, the founding members were Hogia, NL Partner (was acquired by Locus Scandinavia in late 2005), Scania, and Volvo. All actors believed the arrangement was necessary to establish the inter-organizational processes required for continued industry digitalization. The platform initiative was formalized in a researcher-client agreement to secure commitment and specify roles and responsibilities.

A government agency (VINNOVA) provided funding for the collaboration through the project "Value-Creating IT for Road-Haulage Firms" As a first step, the partners decided to focus on reuse and reconfigure architectural knowledge from already established projects that aimed at integrating embedded, mobile, and stationary technologies into coherent digital infrastructures. The researchers identified the ongoing integration projects, and the other platform members provided access to their cases of heterogeneous technology integration, in effect transcending the long-standing tradition of vendors black boxing their integration procedures.

The ongoing integration projects were generally quite modest in terms of technological innovation, and it became apparent that simply reusing and reconfiguring architectural knowledge from different vendors would have a limited effect. In fact, all projects had failed to successfully integrate the involved heterogeneous technologies because of lack of knowledge sharing suggesting that no single vendor had the capacity to develop a comprehensive digital infrastructure of embedded, mobile, and stationary systems. Most of the vendors realized their inability to handle technologies outside their core competency, especially in situations involving technology embedded into vehicles. Hence, the discussion of lessons across integration projects had started to move competing vendors towards closer cooperation.

The researchers' continued analyses of the integration projects showed that proprietary interfaces both supported and inhibited cooperation amongst vendors and haulage firms. The fact that the IT vendors had created those interfaces suggested they realized a need for digital infrastructures that integrated components from diverging sources. The vendors were not able to

control such development to strengthen their competitive positions. But, the different proprietary interfaces also adversely affected cooperation opportunities. These interfaces were published by stationary vendors to allow their embedded and mobile counterparts to connect to their solutions. So, embedded and mobile vendors had to comply with the interfaces if they wanted to help haulers establish integrated digital solutions.

Reflecting the technological frames and market strategies of the vendors of stationary technology, researchers found that the interfaces offered comprehensive support for the stationary systems. In contrast, interface architecture did not support mobile and, particularly, embedded technology and they were therefore at the heart of the mobile-stationary divide that effectively separated relevant actors.

Further explorations suggested that vendors of embedded technology also adopted protective strategies to maintain their competitive positions. Several road haulage firms were not able to evaluate truck performance via their PC-based fleet management systems because inclusion of vehicle sensor data, such as fuel consumption, was hindered by proprietary interfaces truck manufacturers offered. As a result, it was difficult to promote sustainable transport solutions. Insight into these problems with proprietary interfaces further stimulated the members of the platform initiative to create better knowledge sharing opportunities amongst vendors and road haulers.

In addition, the researchers also sought to maintain the commitment from the SRHA and to enroll individuals with enough architectural knowledge on the ongoing digital infrastructure challenge. The researchers therefore attended a number of meetings with the SRHA IT forum to discuss socio-technical issues related to technology integration. Although the expert groups within SRHA appreciated the insights from the researchers, the interactions did not lead to further support from the SRHA. To be able to scrutinize possible architecture candidates for the shared platform, researchers hired former telematics manager at Scania. He was at the time running his own business, ASN IT & Management, offering education about transport process innovation through standardized systems integration to individual road haulage firms and regional road haulage associations. Given his interest and background, he was invited to join the shared platform initiative.

In 2004, a telematics manager from Volvo expressed Volvo's desire to pursue digitalization in a presentation for various actors in the industry. Well aware of Volvo's own problems to build business around embedded technology in its vehicles, he predicted that the already limited IT

investments made by road haulers could easily be reduced even more. What was required was a market place for service innovation that would operate based on modularized digital infrastructures enabled by standardized interfaces. He believed shared platform initiative is a good place to build that market place. Technology vendors also agreed that a standardized industry interface could help resolve the tensions surrounding integration of embedded, mobile, and stationary systems. Finding leaders for changes proved to be challenging. Researchers suggested that customers groups take bigger role. Therefore, the platform initiative sought support from the SRHA, but it turned the invitation down due to competence and resource shortages.

Having abandoned OSGi as integration architecture for the MSI platform, the members of the initiative hired a consultant to identify architectural alternatives. The truck manufacturers (i.e., Scania and Volvo Trucks) emphasized that they preferred architecture based on a standardized interface, which could serve as a layer over their own embedded components with read-only access to a limited set of CAN bus parameters. Because of their high status in the shared platform initiative, the truck manufacturers' demands effectively reduced the scope of the project's agenda. Vehco planned to help haulage operations with their environmental reports by combining embedded truck data with stationary route and order management data. The truck manufacturers' refusal to make embedded data accessible beyond the FMS standard meant that Vehco's visions could not be realized. At this time, following the decision to drop the OSGi architecture, Gatespace Telematics left the MSI initiative.

Examining successful custom integration projects that MSI members had implemented for road haulers, the consultant identified the Pharos Mobile standard as the most promising architecture for the MSI platform. Pharos Mobile was an interface that had been developed for contractor haulers specializing in package delivery. These players were larger than the road haulers but smaller than global logistics providers such as DHL and Schenker. Nevertheless, they executed routine and pre-defined transport assignments with little variation in information needs.

 The standard relied on XML messaging to integrate data across technologies and several MSI members were already familiar with it. E-Com Logistics, the developer of Pharos Mobile, was therefore invited to run a workshop for MSI members. While the members recognized the merits of a messaging-based architecture, they nevertheless noted that the Pharos Mobile message schemas (i.e., their content and structure) were likely to require significant modifications, as noted in a report:

> "Developed by e-Com Logistics, the Pharos Mobile is a standard specifically intended for transports carried out by contractors of haulers. For us the problem is that it's too large, too detailed, but yet too small… its focus simply is on cargo/package transports."(Project report[2], October 11, 2004)

In the summer of 2004, the MSI members concluded that it would be easier to develop a standard from scratch than to adapt Pharos Mobile. However, they were committed to adopting XML (Extensible Markup Language) for their interface protocol and web services (WS) as the architecture for the platform core. Most of the technology providers in the MSI consortium had experience of WS and they were either already using XML as the data exchange format or were trying to comply with it. As a vendor of stationary technology that had considerable experience with WS-based mobile-stationary integration, Hogia offered its XML message format to the MSI consortium. Hogia's proprietary XML structure soon became the baseline for the platform's standard interface.

Imbrication #4: Material → Human

Integration by means of a WS architecture is accomplished as follows (Figure 10a): (1) both sender and receiver implement the code to communicate with the web service and to pack/unpack the XML file; (2) the sender prepared the XML file that contains the required data as specified by the MSI standard; (3) the sender sends the XML file to the MSI webserver; (4) after assessing that the XML file conforms to the MSI standards, the MSI web service sends an acknowledgement to the sender; (5) the MSI web service sends the data to the receiver; (6a) upon receipt of the XML file, the receiver sends an acknowledgement to the web service, and (6b) unpacks the XML file, extracting the data and transforming it into the recipient's own data structure.

This architectural logic meant that a vendor did not have to install and load any third-party modules on its infrastructure to connect to the MSI platform. Each vendor simply had to incorporate the send and receive tags into its system module so as to control what data was transmitted in and out of it. This decreased synergistic specificity and core-extension coupling. This loose coupling structure let the vendors choose to which data requests to respond and with what information. Also, because a vendor did not have to share a

---

[2] Report's title is *Beneficial IT development for the haulage industry: standardization of data transport between vehicles and existing systems* (original: Nyttoskapande IT för åkeribranschen: standardisering av datatransport mellan fordon och befintliga system)

data structure with a foreign module at runtime, changes in one did not have domino effect on others.

The standardized XML message format provided the software vendors with an interface that was the same for every vendor. Therefore, every vendor could decide internally how they wanted to design data structures to work with the XML file. Even though most of the vendors had worked with XML and had thorough knowledge of web services, this did not obviate the need for well documented tags and processes.
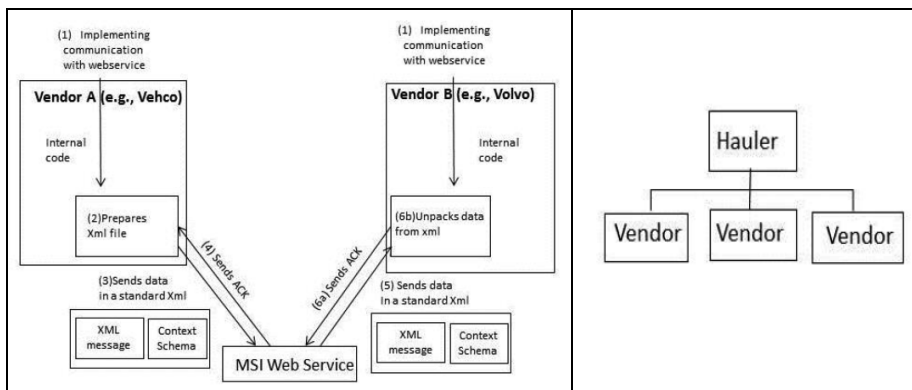

Figure 10 Web Services: (a) Technological architecture (left) and

(b) MSI network structure (right)

The standard was assessed and revised multiple times in light of proprietary interfaces and ongoing integration projects. Revisions can be categorized in three groups:

•To support management of working hours, initial designs included inter-system communication between fleet management monitoring services and data from vehicle sensors. However, members found it difficult to conceptualize the required mapping and management of working hours was removed from the standard.

•Incorporating sensor data from embedded systems could give mobile and stationary vendors competitive advantages. Hence, concerns from embedded vendors resulted in a compromise to only include embedded data relevant to transport assignment. While fuel consumption was included, high-resolution data used for other purposes such as vehicle maintenance and engine development were excluded.

•A context schema was developed to support terminology that reflected firm-specific local conditions. Based on this mechanism, the MSI standard could adapt to specific business terms in any given communication. However, this triggered a discussion of who was responsible for defining and managing the schemas. In the end, it was agreed to assign this responsibility to the stationary vendors.

Due to the modularity of the architecture, which demanded fewer resources from IT vendors to implement, as well as the expectation that every vendor could now act as an integrator on the MSI platform's community-managed core (Figure 10b), the MSI initiative attracted many new members from the industry. These included Consafe Logistics (a stationary provider), as well as three mobile providers, Barkfors, Cybercom, and Pocketmobile. The degree of comfort that the MSI members had with the WS architecture was also noticeable during workshops and meetings; the IT vendors were much more engaged and discussions were less abstract.

The development of the standard accelerated from early 2005. The researchers realized these efforts would put the cooperative spirit within the platform initiative to test. They therefore decided to host all meetings on neutral ground. Vendors, especially those with little previous experience of cooperative development efforts, appreciated the Viktoria Institute as the physical meeting place. To spur further interactions among ecosystem members, a forum for developers from different vendors, called "Mobile-Stationary Online Development Forum", was launched. It did not generate very active participation, but the discussions nevertheless led to significant design decisions. During spring 2005 there were meaningful interactions across vendors and haulers with a commitment to overcome the negative impact of proprietary interfaces. The platform initiative had grown strong enough to resist diverging pressures.

However, the MSI project came to an abrupt and unanticipated halt in September 2005, after the MSI members had been working with its XML data structures for about a year. Hogia announced that it would withdraw from the MSI project due to infringement of its intellectual property rights. Additionally, Hogia threatened to sue the other MSI platform members and to shut down the initiative in order to preserve its competitive position as a system integrator. In an email sent to the Viktoria institute, Hogia expressed their concerns:

> "When we were asked to share our experiences of standardization… we assumed Viktoria was a research institute and therefore voluntarily shared our material with the group. To my knowledge, however, it wasn't part of the agreed plan that Viktoria would then present a standard that competed with us and other providers. … Hogia would never give away something that someone else could further develop into an alternative to our own product."(CEO of Hogia, 19 September, 2005)

IBS, a vendor of enterprise resource planning systems similar to Hogia, did not perceived the MSI platform as a threat, but saw it as an opportunity to increase its install base by streamlining the effort of connecting with disparate technologies offered by a variety of vendors. Instead of continuing to implement integration projects using their own proprietary integration solution, IBS had adopted a new mindset of simplifying system integration through an industry-specific shared platform in order to create more value for their customers:

> "Hogia still argues like… 'we have our own integration
> solutions and our own standard, so why would we take part in
> this effort?' It's simply their business model and making
> specific solutions for each and every customer firm is
> profitable for them. But then you think what a standard
> actually means… it's a solution that many use. IBS has
> already done several integration solutions that build on MSI."
> (Sales manager of IBS, December 5, 2007)

Eventually, Hogia distributed a letter to the platform initiative declaring it
had left the initiative, publicly denouncing legal action, and referring to a
company history of a self-developed open interface and a commitment to
applied research. The TRB spokesperson's active role throughout this process
had eventually made TRB the prominent representative for haulers and
emphasized the centrality of haulers and TRB.

The MSI initiative faced considerable uncertainty because it did not have any
IPR policies in place. However, platform members had come to see the value
of MSI more clearly both for the industry and their own businesses:

> "[The MSI platform] offers its members a competitive
> advantage because it serves as a mechanism that neutralizes
> competition from non-member firms. The more players are
> involved, the better it works." (Marketing Director of
> Pocketmobile, mobile computing vendor, November 5, 2008)

During this period, the platform initiative got funding from SWICT to
transform the activity into a commercial standardization consortium.
Consequently, researchers and members started to design and implement
principles for development, maintenance, and diffusion.

To protect individual MSI member firms against future legal action, the
shared platform initiative was officially transformed into a commercial
industry consortium, called the Mobile Stationary Interface Group (MSIG),
in Fall 2007. It was financed via member fees and developed a formal
organizational structure with a board of directors, a strategy team, and a
technical committee.

10.3 Business Process Module Phase: January 2010 to June 2016

Imbrication #5: Human → Material

Following the establishment of the MSIG, the shared platform initiative received attention in the trade press and its members promoted it at a series of national road transport events.

Increasingly the MSIG members acknowledged that the MSI standard helped them reduce the time and effort needed to integrate data from different vendors' products. Indeed, an increasingly synchronized architectural understanding among software vendors meant that even integration efforts that did not use the MSI platform benefited from the vendors' increased knowledge about each other's' technologies. Hogia soon realized that integration practices were changing and it therefore decided to return to the shared platform initiative.

In addition to the technology providers, there were also major road haulage firms that recognized the benefits that the MSI platform provided them:

> "The MSI standard is an absolute necessity for us to cope with future market requirements. It allows us to spend more time on increasing our market penetration, which will result in improved profitability for ourselves and our customers. It can also help to neutralize (unwanted) competition in the marketplace by lowering switching costs and thereby making technology components easier to replace." (IT director at Samfrakt, a large road haulage firm, August 22, 2006)

In early 2010, one of the largest road haulers in Sweden, LBC Frakt Värmland, put out a request for proposals to integrate its varied systems using the MSI platform. Given the size of the project, several software vendors bid on this assignment, but all of their offerings relied on proprietary interfaces rather than the MSI architecture. LBC Frakt Värmland eventually selected two vendors on the mobile side and Locus Scandinavia for the stationary part of its architecture and tasked them to leverage the MSI standard in the integration.

Unfortunately, the integrators faced difficulties in large part because the flexibility offered by the XML context schema had encouraged the accommodation of too many software vendors' specific integration needs,

thus bloating the interface. LBC Frakt Värmland concluded these problems aggravated the integration situation. They decided to abandon the MSI platform and rely on Locus' proprietary interface. Nevertheless, the vendor was instructed to make its integration solution MSI-compliant.

The outcome was a solution for transport order management, which represented a subset of the processes that the MSI standard supported. MSIG learned that the complexity of system integration could be managed effectively by dividing the MSI standard into modules that dealt with specific business processes. After some consideration, a decision was taken to decompose the standard into four modules, each supporting a different business process.

Imbrication #6: Material → Human

Applying the logic of maximum reusability, MSIG divided the MSI interface along horizontal and vertical lines (Figure 11a): (1) header tags specifying the message (e.g., type, sender, receiver), that each transmission needed, were moved into a 'general' module, which all messages had to inherit to work on the MSI core; and (2) XML tags specifying the parameters related to one of four business processes, i.e., order management, resource management, route optimization and reroute management ended up in separate modules. The order management module dealt with order fulfillment, i.e., scheduling deliveries so that they occurred within the customer-specified time frame and calculating the delivery costs of an order. The purpose of the resource management module was to store information about the hauler's heterogeneous array of resources that needed to be tracked and accounted for during an order's fulfillment (e.g., staff, trucks, gasoline). Use cases for the route optimization module included sequencing deliveries so that transportation costs were minimized, taking into consideration the delivery window specified by the customer as well as traffic information. An extension of route optimization was the reroute module, which afforded the dynamic, just-in-time recalculation of the optimal route as transport conditions changed, e.g., a road accident or mechanical problems.
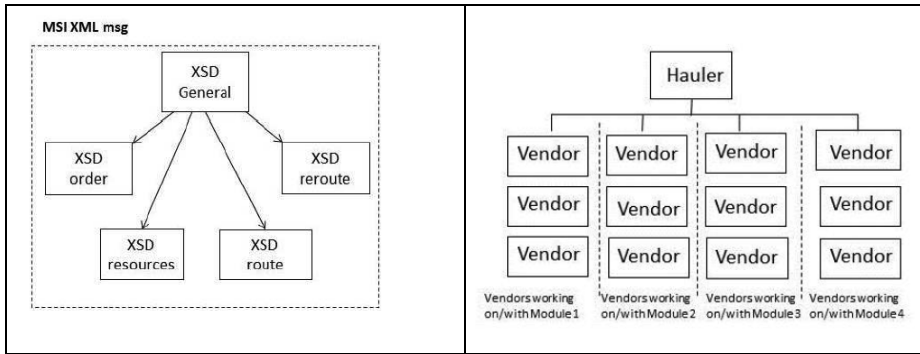
Figure 11 Business Process Modules:

(a) Technological architecture (left) and (b) MSI network structure (right)

While the MSI interface developed during the WS architectural phase represented the starting point for the BPM architecture, the more modular BPM interface was both more streamlined and more extensive. Given the difficulties with conformability caused by numerous, vendor-specific variants of parameters that were almost identical to each other, the re-design of the XML message templates harmonized the interface, standardizing the format and meaning of each variable. The simplification of the interface, coupled with improved documentation, significantly improved its conformability.

Additionally, by limiting the design focus to a specific business process, the parameter set grew to afford a deeper, more variable and subtle representation of a business process. Many of these new XML tags were anticipatory in the sense that the need for them had not yet been expressed but was likely to emerge in future. Thus, the IT vendors competing for the integration work in any one of the four business process verticals had the opportunity to distinguish themselves by leveraging some of these new parameters. Notably, by creating a loosely coupled architecture, increased modularization also afforded generativity.

The more process-oriented BPM architecture made the road haulage industry more appealing to new entrants that had capabilities relevant to the industry. While this increased competition among the players in a given business process vertical (e.g., order management), it also created network effects that made the IT vendor capable of leveraging other players' offerings in creative ways. These potential network effects, made possible through the modularity

of the interface, moderated the competition among the vendors in a given vertical (Figure 11b).

One of the new entrants to the MSIG was DPS, a vendor of route optimization software recognized as having developed one of the best route optimization algorithms in Europe. The modular architecture and the flexibility in integration that it promised created the conditions for DPS to consider entering the Swedish road haulage market for the first time:

> "To be honest I think everybody in road transport should have tried to grab what we're doing like fifteen years ago… But they haven't so that's why MSI appears so interesting to us. Given the language it offers and its focus on flexible technology integration, we eventually get the leverage our product deserves. We need this standard to reduce the barriers and materialize the plug and play vision… then we're all set and ready to go." (DPS managing director, August 18, 2010)

While the order management module had been largely developed by Locus for LBC Frakt and was therefore considered relatively complete, and the resource and re-route management modules were dependent on the implementation of the order management and route optimization modules, the latter became the focus of attention during the development of the BPM architecture. Even though the order management module was considered the most crucial of the road haulers' integration requirements, the urgency of the route optimization module was buoyed by renewed emphasis on environmental sustainability.

Despite DPS's newcomer status in the MSIG community, it took on the leadership of the route optimization module. Even though this position implied that DPS would have to cooperate with the participants in this particular vertical, its managing director explained why the company expected competition with these vendors to be moderate at best:

> "We actually welcome openly sharing our expertise. It's likely it would lead to potentially more business negotiations for us and I expect us to win them all in the end. We've learned it takes a lot of time and resources to develop an effective optimization engine, so I guess others understand they're well behind us… We're therefore not afraid competition would intensify in that way." (DPS managing director, January 26, 2012)

Nevertheless, despite initial support from all MSIG members, the development of the route optimization effort ran afoul of the truck manufacturers' fundamental unwillingness to make sensor data beyond the requirements of the FMS standard available. Thus, while DPS anticipated little competition from other IT vendors, the truck manufacturers did not strictly fall into this category. Instead, as owners of the vehicle sensor data, they were in a position to limit the scope of the MSI route optimization module thus restricting the value creation potential of the IT vendors who could now more easily offer services to the road haulers thanks to the modular architecture. Once again refusing to cooperate fully in the MSI platform initiative, Volvo Trucks and Scania left the MSIG this time. Before departure, in 2011, they had already banded together to develop an integration effort with similar goals to MSI with DHL.

The emergence of "Apps" as a new architectural vision, however, complicated the completion of the modularization of the standard and its subsequent diffusion. In fact, the truck manufacturers started to phase out gradually. Volvo had originally joined the initiative with the ambition to make it more international. However, the slow progress in combination with the clear focus on small Swedish road haulage firms meant that Volvo started to question its role in it. In the midst of everything, the platform initiative faced yet another emerging major technology architecture shift, namely Apps. The proponents of this architectural idea envisioned that apps would resolve many of the integration difficulties that plagued the transport industry in the past. Consequently, trying to secure its foothold in this emerging market, Volvo started to move away from the strategies the ongoing platform initiative pursued.

Platform members were still busy fine-tuning the modularized XML-standard and did not pay enough attention to the implications the new technology architecture shift presented to them. Eventually other software providers started to lose interest as well. They felt they had achieved the goal of the platform initiative (their objective was to be able to integrate with other software in the market and have a better understanding of each other's software) and they realized a new technology integration landscape was emerging rapidly.

Despite the truck manufacturers' departure, the modularization effort of the MSI interface continued and the four business process modules were handed over to MSIG in late 2012. However, IT vendors' interest in the platform waned just like the truck manufacturers'. They made no effort to push the diffusion of the MSI business process modules for the integration of the road

haulers' three islands of technology; instead, they returned to the pre-MSI practice of building custom and proprietary interfaces to the systems being integrated for a given hauler. This could be explained, in part, by their improved knowledge of others' systems, which made it more feasible to implement their proprietary integration solutions at competitive rates. Furthermore, given the truck manufacturers' repeated refusal to make available embedded sensor data, the IT vendors had become somewhat disillusioned about the prospects of developing truly innovative solutions for road haulers, e.g., just-in-time inter-firm load sharing.

MSIG's attempts to reenergize its members in order to diffuse the MSI platform faced considerable roadblocks. Given the road haulers' diversity and their lack of technological sophistication, they were unable to express their emerging needs. Additionally, many IT vendors were increasingly aware that the MSI platform was not readily reusable in other (e.g., international) settings, making it difficult for them to recoup their investment in the MSI platform, especially in light of the small size of the Swedish road hauler market. Given these overwhelming odds, the MSIG's board of directors decided to terminate the shared platform initiative in Spring 2013.

11 DISCUSSION

Industrial products and processes are increasingly enabled by computing and communication capabilities based on digital sensors, networks, processors, and software. Given that the pervasiveness of such technologies reduces the gap between the digital and physical worlds (Lyytinen & Yoo, 2002), organizations are able to store, mobilize, and interpret information sources unavailable in the past (Yoo, 2010; Yoo et al., 2012). Smart trucks equipped with a GPS chip, two-dimensional barcodes, and RFID, for example, can send and receive information about their states, locations, and movements. These newfound information sources help logistic partners reshape and optimize their integrated supply chains by recognizing alterations in inventory levels, market demands, and transport constraints.

Such digitally enabled capabilities create opportunities for new behaviors not seen in the past, ultimately changing the concept of a service. However, although IT-enabled services are truly intangible, their co-production relies on processes that involve a complex array of heterogeneous and often autonomous technological and social elements. Technology standards can facilitate co-evolution of these items and thereby help build and sustain shared platform initiatives that afford industry players requisite opportunities to create new IT-based value in service delivery (Andersson et al., 2008; Lyytinen & Newman, 2008). Yet, we know little about the role of technology standardization in the longitudinal evolution of digitalization within specific industries where these standards enroll organizations into dynamic ecosystems that energize or inhibit the emergence of innovative services.

Against this background, my research concerns a shared platform initiative that led to a technology standard in the Swedish road haulage industry. From the start of the process back in 2002, the project aimed at diagnosing and resolving problems associated with the adoption of embedded, mobile, and stationary IT systems in road haulage firms. The main issue identified was the existence of proprietary, incompatible systems that were widely resisted by haulage firms (Andersson & Lindgren, 2005). While technology vendors were reluctant to transfer knowledge and power to user organizations, the haulage firms had difficulties to prioritize strategic considerations mainly because of their focus on short-term execution of everyday operations. Indeed, the SRHA did not have a clear idea of how to support the ongoing digitalization of their members, which meant that calls from the researchers for help remained unanswered. Emergence of OSGi provided platform members with interoperability opportunities. It accelerated cooperation

between competitor members of the consortia. However, it did not allow members to choose their level of data openness.

Later, however, the platform initiative experienced a breakthrough when Volvo showed interest in the project and asked members to join the shared platform. Not only did encourage the technology vendor community; it also brought haulage firms to the table because TRB Sweden saw this as an excellent opportunity to pursue the standardization agenda it had been promoting for long. Consequently, given the lack of standardized ways to integrate heterogeneous technologies into digital infrastructures, it was decided that IT vendors, haulage firms, transport industry representatives, and action researchers would jointly develop a technology standard (Andersson et al., 2008).

The introduction of the group to Web Services and XML standard encouraged members to work closer on the development of the platform and standardizing the interface. This architecture gave platform members the interoperability opportunities while giving providers more control over their openness degree. This decreased their perceived competition and accelerated the development procedure.

Throughout the development process, the emerging standard served as a boundary object (Carlile, 2002) that allowed the involved actors to reuse and reconfigure architectural knowledge embedded into current practices and to co-create visions for digital industry infrastructures. The different versions of the standard embodied the latest knowledge created and enabled continued conversations about innovative business processes. Hence, the standard was shaped iteratively through an unfolding industry ecosystem in which individuals and organizations alike engaged in perspective making and perspective taking (Boland & Tenkasi, 1995) to learn from each other, while at the same time maintaining their own understanding (Boland, Lyytinen, & Yoo, 2007). That is, the process was shaped through the identities and core competencies of the involved actors and how that in turn reshaped the relationships between them. While the boundaries between vendors of embedded, mobile, and stationary technologies initially were anything but clear, the establishment of MSI Group helped create transparency and facilitated new patterns of cooperation. Indeed, this standardization consortium helped its members position themselves, ultimately creating better conditions for joint implementation projects. However, the knowledge they gained from each other's business processes and platform architectures did not have desirable outcomes for all members involved, e.g., it threatened Hogia's business strategy in phase 2.

Clearly, a key outcome of the standardization process was the establishment of the MSI Group. As a commercial consortium of vendors of embedded, mobile, and stationary transport systems as well as truck manufacturers and road haulage firms, the group made the MSI standard available to the Swedish road transport industry. While there are examples of road haulers that have completed MSI-based integration projects, the standard was also increasingly present in situations where such firms requested offerings from vendors.

Modularization of platform architecture motivates higher generativity degree (Yoo et al., 2012) however shared platform governance should not allow for a third party to get control over the interface design. Such governance practices threaten platform's evolution. Adopting the design for complementors should not take the center stage so that the design of platform misses the technological shifts in the industry. Such precautions are of higher importance for shared platform there compatibility of platforms is the reason of shared platform existence.

Several IT vendors have implemented the standard in their software packages, and truck manufacturers have promoted it globally throughout their organizations. Despite the platform not being used, the MSI Group was seen by many as a nexus of digital innovation in the road transport industry. The group represented a physical and cognitive arena that operated at the industry level and catered for value-creating interactions that transcended structural boundaries previously undermining complementary approaches.

My presented analysis of coopetitive dynamics within the MSI initiative suggests shared platforms can serve as a neutral arena ("trading zone") for actors to cooperate with their competitors with periods where these two modes of interaction are overlapping and periods where one of these two is dominating. Shared platform members who undertook competitive behaviors within coopetitive activities when they sought to develop a standard that would create value for all involved parties characterized the platform dynamics. My analysis traced this coopetitive dynamic through platform evolution and identified the emerging technology architecture shifts that challenged enacted governance strategies, ultimately leading to dynamic patterns of coopetition in the platform ecosystem over time (Gawer, 2014; Tiwana, 2015).

My findings suggest actors in technology intensive industries need to strategize for the emergence of shared platforms, even before stable industries are formed through the diffusion of technology standards. Network effects (Suarez, 2004), entry of start-ups with new technologies (Anderson & Tushman, 1990), and the influence of complementors (Teece, 2007) and others in institutional fields typically characterize such platforms (Garud et al., 2002). Here the level of uncertainty experienced by actors is likely to be higher than during the era of incremental change, and some have suggested that the speed of change is also significantly higher (Christensen, Craig, & Hart, 2001). My findings further suggest this era requires significant vigilance and agility on the part of participating actors. They need to continually scan and monitor their own ecosystems and other relevant ecosystems to learn about developments in the product market sector as well as the relevant technical and institutional sectors. They also need to be agile in their responses to their competitors to successfully embrace the inherent logic of platform coopetition (Gawer, 2014; Tiwana, 2015).

The lessons I have learned also indicate that the engagement in shared platform coopetition requires actors to devise their strategic positions properly in the technological landscape. A key issue in platform initiatives is the timing of players' entry into the platform or the technological field (Christensen et al., 2001; Suarez & Utterback, 1993; Tegarden, Hatfield, & Echols, 1999; Wareham et al., 2014). These actors are confronted with the challenge of predicting future technology architecture shifts, which is a genuinely difficult task given the competitive uncertainty characterizing technology change processes. Suarez (2004) argues very few technologies today can work in isolation, and some form of cooperation with other technologies is usually required to advance a sustained competitive advantage. My findings show that such platform coopetition (enabled by technology standards), however, can reduce resource heterogeneity in an ecosystem that eventually may culminate in intensified competition between cooperating actors. This form of competition mainly originates from technological changes that enhance a firm's capability and position while they render one or more coopetitiors' capabilities obsolete (Afuah, 2002).

Adopting Gawer's (2014) view of digital platforms as an emergent organizational form composed of (1) a network of actors that cooperate in the generation of value and compete in its appropriation (Eisenmann et al., 2011; Tiwana, 2015), and (2) a technological architecture consisting of a core, a standardized interface, and extensions (Baldwin & Woodard, 2009; Le Masson et al., 2011; Tiwana et al., 2010), I seek to theorize the entanglement of the social and material aspects of shared platforms. Consistent with

sociomaterial theorizing (Orlikowski & Scott, 2008), which has not yet been applied to empirically investigate the evolution of shared platforms, the purpose of this study is to answer the following research question: "How do the participants' coopetitive behavior and the platform's technology architecture reciprocally shape the evolution of a shared platform?"

Drawing on an imbrication lens (Leonardi, 2011), my analysis of a twelve-year initiative to develop a shared platform for the Swedish road haulage industry reveals insights into: (1) the opposing interests of stakeholders manifest in the construction of constraints and affordances, (2) archetypes of shared platform organizations, and (3) the materialization of architectural ideas during shared platform development. Finally, I conclude by articulating the contributions our research makes to both the theory and practice of managing the evolution of shared platforms.

11.1 Opposing Stakeholder Interests Manifest in Imbrication Pairs

Inspecting the sequence of constraints that triggered changes in technology and affordances that triggered changes in the coopetitive dynamics in the imbrication framework (Figure 8), I note that they alternated pairwise between the concerns of the IT vendors and their customers, i.e., the road haulers. Specifically, a constraint perceived primarily by the customer (e.g., propriety interfaces) motivated a material change (e.g., OSGi platform) that afforded road haulers the ability to source integration services from a single vendor (i.e., Vehco). This centrally-owned architecture, however, represented a constraint for the IT vendors (i.e., mediation of customer relationship) and the material changes to the architecture (i.e., a messaging platform based on web services) afforded these stakeholders the opportunity to each offer integration services. This was achieved, in part, by designing a bloated XML interface that accommodated the parameters that each vendor needed and previously had access to via their proprietary interfaces (rather than harmonizing them).

The last imbrication set was triggered by the constraint this overly complex interface created for customers who sought to use the MSI platform for their system integration needs. The resulting BPM architecture was perceived as beneficial because it afforded them advanced and integrated information services (e.g., route optimization), but it proved challenging for the IT vendors who found it difficult to offer the complete suite of services given the market fragmentation. Additionally, based on the IT vendor's demands

that the road haulers compensate them for future platform development (given that the size of the Swedish road haulage industry was too small for the IT vendors to recoup their investment), I contend that the next imbrication would have again reflected the IT vendors' interests.

This pattern of toggling between the interests of the customers and the IT vendors, highlights that in the development of shared platforms, it is not only the conflicting interests among coopetitive IT vendors that need to be understood and managed, but also those between customer and vendor groups. There is a risk of overlooking the customer-vendor tensions that are inherent in shared platforms (Markus et al., 2006), especially when their opposing interests are subtle or masked by the customer's lack of technological expertise, which places them in a less powerful position during the development effort. Switching back and forth between privileging different stakeholders' interests in each imbrication pair might prove an effective strategy for keeping these stakeholders engaged (Baldwin & Woodard, 2009).

11.2 Archetypes of Shared Platform Organizations

The development of the MSI shared platform consisted of three organizing initiatives, each characterized by a particular architecture. Categorizing these architectures according to the features of their core and their interface, I can distinguish them according to two dimensions (Figure 12): 1) the degree of synergistic specificity of the core and the extensions (Schilling, 2000), which I refer to here as core-extensions specificity, and 2) the conformability of the interface (Tiwana, 2015; Sanchez & Mahoney, 1996). Placing each of the three MSI architectures (i.e., material) into this 2x2 framework and examining the implications of these architectures for coopetition (i.e., social), allows us to derive three archetypes of shared platforms as sociomaterial, organizational forms.
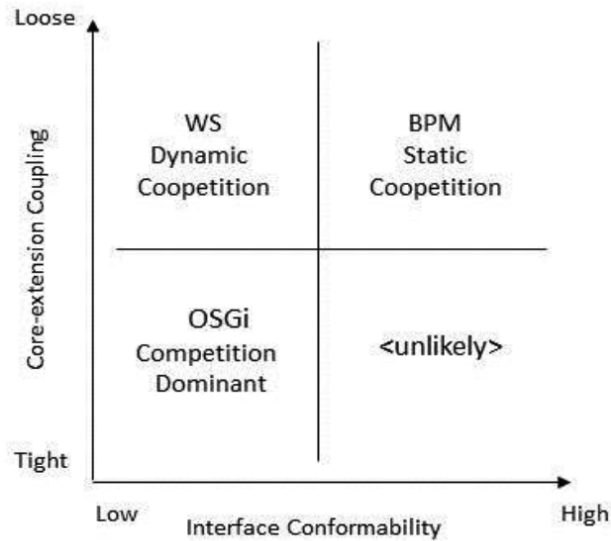
Figure 12 Sociomaterial configurations of the shared platforms

While the OSGi architecture was classified as having high core-extension specificity, the web service architectures (i.e., WS and BPM) were considered low on that dimension. This is because, in the OSGi architecture, the core and the extensions were optimized to work effectively with one another, making each vendor's extension specific to the core. This high interdependence between the components of the core and vendors' extensions demanded by the platform architecture was met with resistance by the IT vendors. They expressed concern about their system security with regard to the client-side JAR files that could be updated remotely in order to accommodate changes in the platform's core. In contrast, the WS architecture reduced the core to a messaging service for XML files exchanged among platform members. This meant that there was low core-extension specificity (i.e., low coupling). The design of the extensions was thus highly independent of both the platform core and other vendors' systems.

The interface dimension of the platform architectures was assessed in term of its conformability, that is, the relative ease with which extensions can seamlessly coordinate with and through the platform core. A highly conformable interface is characterized by being clearly specified, unambiguous, stable, well documented, and standardized (Tiwana, 2015; Sanchez & Mahoney, 1996). A key implication of high interface

119

conformability is that the coordination among information-exchanging parties is simplified, thus encouraging larger numbers of diverse extension providers to join the platform and increasing its value (Boudreau, 2010).

Both the OSGi and web service architectures exhibited low conformability, largely because their interfaces were non-standard and poorly specified. Specifically, the OSGi interface relied on data structures that were specifically tailored to each IT vendor's system. The web service interface had low conformability as all the parameters required by different vendors were contained in a single XML structure without sufficient documentation and guidelines. This made it difficult for vendors who were expected to complete the XML template with data, to know which parameters to supply a requestor. Vendors whose systems were to be integrated were thus forced to engage in off-platform coordination. In contrast, the Business Process Modules architecture was highly conformable as the parameters outlined in the XML templates were not only harmonized (thus more standard and documented), but also limited to a specific business model, thus rendering them less ambiguous and allowing for better documentation.

Locating the three MSI architectures into the 2x2 matrix that this dimensionalization of the platform produces, I can now theorize the coopetitive dynamics associated with each of them in order to develop three archetypal organizational forms (or sociomaterial configurations) that shared platforms can take. These are the centrally-controlled, distributed, and modularized platform.

My analysis suggests that centrally-controlled shared platforms (e.g., OSGi) generate competition-dominant coopetition in large part because the vendor controlling the platform mediates the other vendors' customer relationships. While such a centrally-controlled platform is generally attractive to the customer because all their integration needs are met by a single platform provider, it represents a significant threat to the mediated IT vendors. Given the competitive threat this architecture poses to the vendors, one would expect them to band together against the vendor that manages the platform core and to withhold cooperation in an effort to protect their own competitive position. As one would expect of a competition-dominant organization, innovation is likely to be low.

The distributed shared platform (e.g., WS) is associated with dynamic coopetition, which is the most innovative of the organizational forms as it balances moderate cooperation with moderate competition (Bengtsson et al., 2010). The architecture's low core-extension specificity means that barriers

to entry are dissolved and more vendors are likely to seek access to the network, thereby increasing the availability of not only innovative ideas but also competition. In addition, as every vendor with a software installation in a customer's IT infrastructure is now a potential integrator, the competition in the distributed architecture is likely to be fierce, further spurring innovation as competitors seek to differentiate themselves.

However, the interdependence among the vendors, where one acts as the integrator for one customer but the integratee for another, requires that the vendors generate sufficiently strong bonds so that their counterparts feel compelled to cooperate in future. The cooperation spurred by this co-dependence is likely to be buoyed by the need for off-platform coordination due to the interface's low conformability. The inter-organizational relationships that develop during such coordination serve as a resource for innovation that improves the industry as a whole.

Modular shared platforms (e.g., BPM) are associated with static coopetition. With both competition and cooperation being weakened by the material conditions of the architecture, this organizational form lacks the innovative and productive energy of the distributed shared platform. This seems counter-intuitive, since an architecture characterized by high conformability and low core-extension specificity is the most desirable. Why does it therefore not produce an organizational form optimal for innovation?

Since a highly conformable interface manages data coordination among companies whose systems are being integrated, off-platform communication is made redundant, thus reducing the opportunity to build strong inter-firm bonds and cooperation. Additionally, competition is lowered as the modularized interface limits competition to the verticals created by the modules (e.g., route optimization). Very few vendors - if any - are capable of offering integration in the entire suite of business processes.

Figure 12 includes a cell that is labelled "unlikely" because an interface with high conformability is typically highly modularized, making it inconsistent with a platform core that is tightly coupled with its extensions (Schilling, 2000).

11.3 The Materialization of Architectural Ideas

A key characteristic of shared platforms is that their ultimate success relies on producing value for a customer by aggregating a diverse and unique set of services in a single place. The development of the shared standard-based architecture requires involvement from a diverse set of actors, whose interests may be orthogonal to each other (Steinfield et al., 2011). A key challenge for the evolution of a shared platform therefore is to begin materializing design ideas, even if the members of the initiative are not in full agreement and are trying to win the platform dominance battle (Chen, Qian, & Narayanan, 2017). Having something tangible (e.g., code, data structures) to focus the platform member's attention and to align their overarching goals is particularly important in shared platforms, where membership tends to be quite fluid (cf. Nambisan, Lyytinen, Majchrzak, & Song, 2017).

The MSI project dealt with this challenge by relying on a vendor that had prior experience with a candidate technology to lead the development of the envisaged architectural solution. For example, the OSGi architecture was advanced by Gatespace who had implemented some projects with Volvo Trucks using this integration technology. Hogia was then the source of the Web Service architecture design and the XML interface in the distributed platform architecture. Finally, DPS leveraged its expertise with data integration for route optimization to spearhead the modularization of the XML interface.

While this approach of revolving technology leadership was effective in focusing the attention of the MSI members and keeping the platform's development moving, it also posed considerable challenges. Given that the technology leader exerts some control over the integration, this affects the complementors' competitive positions and evokes some kind of a response (Narayanan and Chen 2012). In the case of the centralized architecture, the vendors took a competition-dominant stance, whereas competition and cooperation were balanced when all vendors had an equal chance to serve as systems integrator, thanks to the WS architecture. Elevating one actor to technology leader thus introduces its own set of coopetitive dynamics, which I have shown to have significant implications for the likelihood of generating and implementing innovations that benefit the industry as a whole (cf. Wareham et al., 2014).

Nevertheless, the technological leader's position in the MSI project was generally unstable. For example, Gatespace withdrew from the MSI project

after embedded technology was ruled out of scope. In the case of Hogia, its initial cooperation-dominant attitude suddenly swung to a more competitive disposition as it threatened to sue the MSI consortium over IP infringement. This suggests that this strategy of speeding the materialization of design ideas along by elevating a specific vendor's technological solution as the starting point for evolving the architecture (i.e., material dimension), may short-circuit the important work of generating a foundation of cooperation among group members (i.e., social dimension).

11.4 Limitations

This study has some limitations that pave the way for the future work. My study is limited to coopetition dynamics toward specific technologies within a particular industry. It examines the work of a single group of actors in the Swedish road haulage industry who focused on the development of the MSI shared platform. My work is thus concerned with the specific issues that rose in this specific context. Future research needs to consider different technology architectures and industry sectors to include requisite variations in how evolution of shared platforms manifest.

My dissertation also focused on a shared platform that finally ended without being used by a large base of customers. Yet, the observed evolution path contains elements familiar to many evolution processes- the need to strike a balance between users and suppliers of technology, the challenge of coordinating heterogeneous stakeholders, the challenge of settling on the common denominator of the varied customer demands, and the difficulties in building relations and momentum to facilitate convergence. Indeed, the Swedish road haulage industry is characterized by coopetition; it is constituted by a plethora of players; and, because many of these represent relatively small firms there is scarcity of innovation resources available. In retrospect, these characteristics definitely affected the research findings, and they should therefore be treated with caution. As a result, future research should investigate the different ways in which industries can establish informal, ad-hoc organizations to effectively orchestrate innovation and development of shared platforms.

12CONCLUSION

Given my reliance on a single, albeit twelve-year case study of a shared platform's evolution, my objective is to generalize our findings to theory, rather than to the population of shared platforms (Lee & Baskerville, 2003). With this goal in mind, I articulate my contributions to research, but also weave in my findings' significance for practice. The latter is particularly salient as consortium-based efforts to solve an industry's communication and integration problems represent the most common organizational form for platform development and standardization (Cargill, 2002).

Research on platforms is the first domain to which my dissertation contributes. Adopting a definition of platforms as an organizational form, this research seeks to overcome the false separation between the technological and social/economic dimension of platforms that is prevalent in this literature (Gawer 2014). Thanks to the detailed and longitudinal data of the MSI platform's evolution, I was able to demonstrate the entangled nature of these two dimensions. Drawing on imbrication (Leonardi, 2011) as my theoretical scaffold for identifying how the platform architectures and the coopetitive relationships among the MSI participants became entangled to form three types of shared platform organizations, i.e., centrally-controlled, distributed, and modular, my research extends recent work on the development of architectural platform solutions (Aanestad & Blegind Jensen, 2011; Grisot , Hanseth, & Thorseng, 2014; Henfridsson & Bygstad, 2013).

While these organizational forms have not been identified and conceptualized before, my sociomaterial lens on platform evolution is certainly not unique to this study. So far, however, only a few papers have developed similar arguments as areas of further study. As my empirical analysis suggests, the development of shared platforms is a highly volatile, complex, and uncertain environment, which undermines participants' ability to make strategic decisions based on predictive rationality. Hence, Koch, and Windsperger (2017) suggest that a key question to answer concerns how heterogeneous actors may achieve competitive advantage by actively shaping the shared technological platform and co-creating value that stems from the synergistic exchange of digital resources and services. De Reuver et al. (2017) argue, however, that it is not obvious how such platform evolution plays out given the distributed model of organization that characterizes a shared platform. I believe my theorizing about emerging organizational forms in shared platform evolution advances the IS field's current understanding of what it

takes for organizations "to learn how to compete and thrive" as members of large-scale platforms (Yoo et al., 2012, p. 1406).

A key implication of adopting a sociomaterial lens to research on the development of shared platforms is that architecture is given material agency (Gawer, 2014). This suggests that there are aspects of a system's evolution that cannot be controlled by more careful planning and/or more intricate designs. Instead, what the technology, in combination with human actors, produces is neither entirely knowable nor controllable. For this reason, the notion of systems development needs to be replaced by the concept of system evolution in a sociomaterial study (cf. Agarwal and Tiwana, 2015).

While I rely on imbrication theory to highlight that perceived constraints trigger technological changes, and perceived affordances trigger changes in routines (e.g., inter-organizational coordination), applying this causal logic to the specific context of shared platforms allows us to refine this imbrication change mechanism. I note a toggling between different stakeholders' interests during the evolution of the MSI platform (cf. Baldwin & Woodard, 2009). I propose that alternating whose interests are primary across the imbrication pairs may constitute an effective strategy for keeping all platform members engaged, despite power differences among them. However, this proposition should be tested empirically in not only shared platform projects, but also other architectural initiatives. The imbrication lens should ideally be applied in such studies, as it provides a powerful conceptual scaffold to segment a development effort into significant design movements, which can then be inspected for whose interests they serve.

Another refinement of imbrication's theoretical change engine relates to the materialization of design objectives (human agency) in share platform initiatives. The strategy of adapting solutions previously implemented by one of the participants, proved problematic for a variety of reasons. These include ambiguities around intellectual property and the adverse effects of one actor's elevated status on the competitive dynamics of the group (Eisenmann, 2008). Indeed, the identification of agile, entrepreneurial responses to clients' needs without compromising the momentum of the platform as a whole, represents a pertinent issue in the platform governance literature (Wareham et al., 2014) Future research on shared platforms might examine the tradeoffs between materializing human agency by developing support for an existing solution and by building agreement among participants, from which a native architectural solution can then emerge.

The implications of these platform-related findings for the management of these emergent organizational forms are significant. The view that technology has material agency suggests that the development of shared platforms needs to exhibit flexibility. It therefore behooves practitioners to adopt agile approaches and to recognize that systems evolve despite human efforts to design and develop them (Agarwal & Tiwana, 2015). The strategy of alternating the priority of different stakeholders' interests in each architecture development phase, reminds practitioners to consider the needs of customers, which might be overlooked in an effort to manage the coopetitive dynamics among the IT vendors. These coopetitive dynamics are easily affected by changes in the relative status of network members (Bengtsson et al., 2010; Ingram & Yue, 2008). Thus, people who are managing the evolution of shared platforms should carefully weigh the costs and benefits of developing a solution by adapting a (proprietary) technology that one of its members has deployed in the past (Eisenmann et al., 2011).

The second domain to which this dissertation contributes is the research on coopetition. Regarding the evolution of a shared platform as a unique opportunity to explore the dynamic interplay between cooperation and competition, I identify the material conditions (e.g., centrally-controlled architecture) under which specific coopetitive configurations (e.g., static coopetition) emerge. Indeed, past research has largely ignored both the material conditions of coopetition (Gawer, 2014), as well as the dynamic interplay of cooperation and competition (Hoffmann et al. 2014). One counter-intuitive finding generated by this analysis is that an architecture that is technologically superior (e.g., modularized architecture) can produce paradoxical effects (cf. Hanseth et al., 2006; Narayanan & Chen, 2012), such as coopetitive dynamics that are suboptimal with regard to innovativeness. The social and material conditions under which such counter-intuitive results are produced in shared platform architectures, represents another fruitful trajectory of future research.

For practitioners, the key implication of my finding that a less-than-perfect architecture produced a coopetitive configuration that was more conducive for innovation is that interfaces with low conformability, which compel platform participants to engage in off-platform coordination, may be conducive for fostering cooperation. As such, it is likely to be generative with respect to innovation. Whether a less-than-perfect core architecture characterized by high core-extension coupling, for example, will produce similarly generative results, represents another opportunity for future research.

Interplay between innovation and social aspects are key feature of platforms. This study advances our understanding of sociotechnical dynamics of shared platforms: The emergence and dynamics of shared platforms that is highly affected by the interplay between coopetition and technology architecture. My study shows complex, interacting, and contradicting actions by an array of heterogeneous actors and architectures form the design of the shared platform. However, this dynamism should be met with proper governance strategies through technological shifts otherwise it turns coopetition relationships into intensified competition. Previous studies on industry platforms have mainly illustrated homogenous milieus while I have contributed a detailed empirical account of how a heterogeneous ecosystem of players within the Swedish haulage industry created a shared platform initiative to exploit the commercial possibilities afforded by integrating embedded, mobile, and stationary IT solutions through new industry-wide infrastructures. This offers a contribution to existing research and offers what Walsham (1995) calls "rich insights" on shared platforms.

The MSI project has been the only place for Swedish road haulage industry actors to cooperate in favor of customers, to this day. Although, ecosystem's platforms are not using the MSI as the communication platform today it played a major role in accelerating integration projects by stabilizing cooperation between actors. However, my results show that letting complementors hijacking shared platform development and inability to meet technological shifts hindered this initiative to hit diffusion. This offers important implications for Innovation leaders managing such shared efforts or actors planning to join standardization consortia. In addition, my analysis shows shared platforms are result of reciprocal action between coopetition dynamics between heterogeneous actors, competing platforms and constantly changing technology and industry dynamics which if governed properly lead to value creation.

This dissertation's main objective is to gain an understanding of how shared platforms as organizational forms, which comprise a technological architecture as well as a network of industry actors that both compete and cooperate with each other to varying degrees, evolve as a sociomaterial configuration over time. Relying on imbrication theory, my analysis of a twelve-year action research project, whose purpose was to develop a shared platform to facilitate the integration of embedded, mobile, and stationary technology in the Swedish road haulage industry, demonstrates that the constitution of the organizational forms that are shared platforms occurred through a series of changes in the technology and the vendors' competitive and cooperative relationships based on a given architecture's constraints and

affordances respectively. I identify three archetypes of shared platform organizations and highlight that the organizational form most conducive to innovation, which is central to a platform's value, relies on a technology architecture mediated by an interface that is deficient with respect to conformability. This counterintuitive result raises interesting questions that future platform research might investigate.

13 PEER REVIEWED WORKS

1) Saadatmand, F., & Lindgren, R. (2014). Technology standardization for transport efficiency: on the greening of frames (extended abstract). IFIP WG8.2 Organizations and Society in Information Systems (OASIS) 2014 Workshop

2) Saadatmand, F., & Lindgren, R. (2015). The Tension between Stabilized Cooperation and Intensified Competition: Greening of Technological Frames in Practice. JAIS Theory Development Workshop

3) Saadatmand, F., & Lindgren, R. (2016, January). The Tension between Stabilized Cooperation and Intensified Competition: Greening of Technological Frames in Practice. In 2016 49th Hawaii International Conference on System Sciences (HICSS) (pp. 327-336).

4) Saadatmand, F. (2016). Open Platform Coopetition: The Paradoxical Tension between Stabilized Cooperation and Intensified Competition. European Conference on Information Systems (ECIS) 2016 Doctoral Consortium, June 2016.

5) Saadatmand, F. (2016). Open Platform Coopetition: The Paradoxical Tension between Stabilized Cooperation and Intensified Competition. Organizational Communication and Information Systems/ a division of Academy of Management (OCIS) 2016 Doctoral Consortium, August 2016.

6) Saadatmand, F. (2016). Open Platform Coopetition: The Paradoxical Tension between Stabilized Cooperation and Intensified Competition. International Conference on Information Systems (ICIS) 2016 Doctoral Consortium, December 2016.

7) Saadatmand, F., Lindgren, R., & Schultze, U. (2017). Evolving Shared Platforms: An Imbrication Lens. In 2017 International Conference on Information Systems (ICIS) proceeding.

REFERENCES

1. *Aanestad, M., & Jensen, T. B. (2011). Building nation-wide information infrastructures in healthcare through modular implementation strategies. The Journal of Strategic Information Systems, 20(2), 161-176.*
2. *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.*
3. *Afuah, A. (2000). How much do your coopetitors' capabilities matter in the face of technological change?. Strategic Management Journal, 21(3), 397-404.*
4. *Afuah, A. (2004). Does a focal firm's technology entry timing depend on the impact of the technology on co-opetitors?. Research Policy, 33(8), 1231-1246.*
5. *Agarwal, R., & Tiwana, A. (2015). Editorial—Evolvable Systems: Through the Looking Glass of IS. Information Systems Research 26(3):473-479.*
6. *Akpinar, M., & Vincze, Z. (2016). The dynamics of coopetition: A stakeholder view of the German automotive industry. Industrial Marketing Management, 57, 53-63.*
7. *Anderson, P., & Tushman, M. L. (1990). Technological discontinuities and dominant designs: A cyclical model of technological change. Administrative science quarterly, 604-633.*
8. *Andersson, M. & Lindgren, R. (2005). The Mobile-Stationary Divide in Ubiquitous Computing Environments: Lessons from the Transport Industry. Information Systems Management, 22 (4), pp. 65-79.*
9. *Andersson, M., Lindgren, R., & Henfridsson, O. (2008). Architectural Knowledge in Inter-Organizational IT Innovation. Journal of Strategic Information Systems, 17, pp. 19-38.*
10. *Armstrong, M. (2006). Competition in two-sided markets. The RAND Journal of Economics, 37(3), 668-691.*
11. *Austin, J. L. (1962) How to Do Things with Words, New York, Oxford University Press.*
12. *Avison, D., Baskerville, R., & Myers, M. (2001). Controlling Action Research Projects. Information Technology & People, 14 (1), pp. 28-45.*
13. *Backhouse, J., Hsu, C. W., & Silva, L. (2006). Circuits of power in creating de jure standards: shaping an international information systems security standard. MIS quarterly, 413-438.*
14. *Bala, H. & Venkatesh, V. (2007). Assimilation of Interorganizational Business Process Standards. Information Systems Research, 18 (3), pp. 340-362.*

15. *Baldwin, A. R., & Bengtsson, M. (2004). The emotional base of interaction among competitors—an evaluative dimension of cognition. Scandinavian Journal of Management, 20(1), 75-102.*

16. *Baldwin, C., & Woodard, C. (2009). The Architecture of Platforms: A Unified View in Platforms, Markets and Innovation (Paperback Ed.), Cheltenham, UK and Northampton, MA.*

17. *Bannister, F. (2002). The dimension of time: historiography in information systems research. Electronic Journal of Business Research Methods, 1(1), 1-10.*

18. *Barad, K. (2003). Posthumanist performativity: Toward an understanding of how matter comes to matter. Signs: Journal of women in culture and society, 28(3), 801-831.*

19. *Barad, K. (2007). Meeting the universe halfway: Quantum physics and the entanglement of matter and meaning. duke university Press.*

20. *Barrett, M., Oborn, E., & Orlikowski, W. (2016). Creating value in online communities: The sociomaterial configuring of strategy, platform, and stakeholder engagement. Information Systems Research, 27(4), 704-723.*

21. *Baumard, P. (2009). An asymmetric perspective on coopetitive strategies. International Journal of Entrepreneurship and Small Business, 8(1), 6-22.*

22. *Beck, R. & Weitzel, T. (2005). Some Economics of Vertical Standards: Integrating SMEs in EDI Supply Chains. Electronic Markets, 15 (4), pp. 313-322.*

23. *Bekkers, R., Duyseters, G., & Verspagen, B. (2002). Intellectual Property Rights, Strategic Technology Agreements and Market Structure: The Case of GSM. Research Policy, 31(7), 1141-1161.*

24. *Bengtsson, M., & Kock, S. (2000). " Coopetition" in business Networks—to cooperate and compete simultaneously. Industrial marketing management, 29(5), 411-426.*

25. *Bengtsson, M., Eriksson, J., & Wincent, J. (2010). Co-opetition dynamics–an outline for further inquiry. Competitiveness review: An international business journal, 20(2), 194-214.*

26. *Bengtsson, M., & Kock, S. (2014). Coopetition—Quo vadis? Past accomplishments and future challenges. Industrial Marketing Management, 43(2), 180-188.*

27. *Bengtsson, M., & Raza-Ullah, T. (2016). A systematic review of research on coopetition: Toward a multilevel understanding. Industrial Marketing Management, 57, 23-39.*

28. *Bengtsson, M., Kock, S., Lundgren-Henriksson, E. L., & Näsholm, M. H. (2016). Coopetition research in theory and practice: Growing new theoretical, empirical, and methodological domains. Industrial Marketing Management, 57, 4-11.*

29. *Besen, S. M., & Farrell, J. (1994). Choosing how to Compete: Strategies and Tactics in Standardization. Journal of Economic Perspectives, 8(2), 117-131.*

30. *Bhattacherjee, A., & Premkumar, G. (2004). Understanding changes in belief and attitude toward information technology usage: a theoretical model and longitudinal test. MIS quarterly, 229-254.*

31. *Bloch, M. (1953). The historian's craft. New York: Vintage Books.*
32. *Boland Jr, R. J., & Tenkasi, R. V. (1995). Perspective making and perspective taking in communities of knowing. Organization science, 6(4), 350-372.*
33. *Boland Jr, R. J., Lyytinen, K., & Yoo, Y. (2007). Wakes of innovation in project networks: The case of digital 3-D representations in architecture, engineering, and construction. Organization science, 18(4), 631-647.*
34. *Boudreau, K. (2010). Open Platform Strategies and Innovation: Granting Access vs. Devolving Control. Management Science, 56(10), 1849-1872.*
35. *Bouncken, R. B., Gast, J., Kraus, S., & Bogers, M. (2015). Coopetition: a systematic review, synthesis, and future research directions. Review of Managerial Science, 1-25.*
36. *Braa, J., Hanseth, O., Heywood, A., Mohammed, W., & Shaw, V. (2007). Developing Health Information Systems in Developing Countries: The Flexible Standards Strategy. MIS Quarterly, 31 (Special Issue), pp. 381-402.*
37. *Bremmer, R. (1999). Cutting-edge platforms. Financial Times Automotive World, 9, 30-38.*
38. *Bremmer, R. (2000). Big, bigger, biggest. Automotive World, 6.*
39. *Bryant, A., Black, A., Land, F., & Porra, J. (2013). What is history? What is IS history? What IS history? ... and why even bother with history? Journal of Information Technology, 28(1) 1-17.*
40. *Cargill, C. F. (2002). Uncommon Commonality: A Quest for Unity in Standardization. In S. Bolin (Ed.), The Standards Edge (pp. 29-39). Ann Arbor, MI: Bolin Communications.*
41. *Carlile, P. R. (2002). A pragmatic view of knowledge and boundaries: Boundary objects in new product development. Organization science, 13(4), 442-455.*
42. *Ceccagnoli, M., Forman, C., Huang, P., & Wu, D. J. (2012). Cocreation of Value in a Platform Ecosystem: The Case of Enterprise Software. MIS Quarterly, 36(1), 263-290.*
43. *Cecez-Kecmanovic, D., Galliers, R. D., Henfridsson, O., Newell, S., & Vidgen, R. (2014). The sociomateriality of information systems: current status, future directions. MIS Quarterly, 38(3), 809-830.Chen, M. J. (2008). Reconceptualizing the competition-cooperation relationship: A transparadox perspective. Journal of Management Inquiry.*
44. *Ciborra, C. U., Braa, K., Cordella, A., Dahlbom, B., Failla, A., Hanseth, O., Hepsø, V., Ljungberg, J., Monteiro, E., & Simon, K. A. (2000). "From Control to Drift: The Dynamics of Corporate Information Infrastructures". Oxford University Press, Oxford.*
45. *Chen, M. J. (1996). Competitor analysis and interfirm rivalry: Toward a theoretical integration. Academy of management review, 21(1), 100-134.*
46. *Chen, P. Y., & Forman, C. (2006). Can vendors influence switching costs and compatibility in an environment with open standards?. MIS quarterly, 541-562.*

47. *Chen, M. J., Kuo-Hsien, S. U., & Tsai, W. (2007). Competitive tension: The awareness-motivation-capability perspective. Academy of Management Journal, 50(1), 101-118.*

48. *Chen, T., Qian, L., & Narayanan, V. K. (2017) Battle on the Wrong Field? Entrant Type, Dominant Designs, and Technology Exit. Strategic Management Journal, doi: 10.1002/smj.2669*

49. *Chin K, Chan B, & Lam P (2008) Identifying and prioritizing critical success factors for coopetition strategy. Ind Manag Data Syst 108(4):437–454.*

50. *Chellappa, R. K., Sambamurthy, V., & Saraf, N. (2010). Competing in crowded markets: Multimarket contact and the nature of competition in the enterprise systems software industry. Information Systems Research, 21(3), 614-630.*

51. *Chang, C. & Jarvenpaa, S. (2005). "Pace of Information Systems Standards Development and Implementation: The Case of XBRL". Electronic Markets, 15 (4), pp. 365-377.*

52. *Christensen, C.M. (1997) The Innovator's Dilemma When New Technologies Cause Great Firms to Fail, Harvard Business School Press*

53. *Christensen, C., Craig, T., & Hart, S. (2001). The great disruption. Foreign Affairs, 80-95.*

54. *Christiaanse, E., & Rodon, J. (2005). A multilevel analysis of eHub adoption and consequences. Electronic Markets, 15(4), 355-364.*

55. *Corti, L. (2007). Re-using archived qualitative data–where, how, why?. Archival Science, 7(1), 37-54.*

56. *Cusumano, M. A., & Nobeoka, K. (1998). Thinking beyond lean: how multi-project management is transforming product development at Toyota and other companies. Simon and Schuster.*

57. *Cusumano, M. (2010). Technology strategy and management The evolution of platform thinking. Communications of the ACM, 53(1), 32-34.*

58. *Cusumano, M., Mylonadis, R., & Rosenbloom, R. (1992). Strategic Maneuvering and Mass-Market Dynamics: The Triumph of VHS over Beta. Business History Review, 66(1), 51-94.*

59. *Damsgaard, J. & Truex, D. (2000). Binary Trading Relations and the Limits of EDI Standards: The Procrustean Bed of Standards. European Journal of Information Systems, 9, pp. 173-188.*

60. *Das, T. K., & Teng, B. S. (2003). Partner analysis and alliance performance. Scandinavian journal of management, 19(3), 279-308.*

61. *David, P. A. (1995). Standardization Policies for Network Technologies: The Flux between Freedom and Order Revisited. In R. W. Hawkins, R. Mansell & J. Skea (Eds.), Standards, Innovation and Competitiveness: The Politics and Economics of Standards in Natural and Technical Environments. Aldershot, UK: Edward Elgar.*

62. *Davison, R. M., Martinsons, M. G., & Kock, N. (2004). Principles of Canonical Action Research. Information Systems Journal, 14, pp. 65-86.*

63. *de Vries, H. J. (1999). Standardization – A Business Approach to the Role of National Standardization Organizations. Kluwer Academic Publishers, Boston.*

64. *De Reuver, M., Sørensen, C., & Basole, R. C. (2017). The Digital Platform: A Research Agenda. Journal of Information Technology, doi:10.1057/s41265-016-0033-3*

65. *Doyle, R. (1997). On beyond living: Rhetorical transformations of the life sciences. Stanford University Press.*

66. *Dowling, M. J., Roering, W. D., Carlin, B. A., & Wisnieski, J. (1996). Multifaceted relationships under coopetition description and theory. Journal of management inquiry, 5(2), 155-167.*

67. *Easton, G. (1990). Relationships among competitors. The interface of marketing and strategy, 57-100.*

68. *Easton, G., & Araujo, L. (1992), Non-economic exchange in industrial network, in Axelsson, B. and Easton, G. (Eds), Industrial Networks a New View of Reality, Routledge, London.*

69. *Eaton, B., Elaluf-Calderwood, S., Sorensen, C., & Yoo, Y. (2015). Distributed tuning of boundary resources: the case of Apple's iOS service system. MIS Quarterly: Management Information Systems, 39(1), 217-243.*

70. *Eisenmann, T. R. (2008). Managing Proprietary and Shared Platforms. California Management Review, 50 (4), 31-53.*

71. *Eisenmann, T., Parker, G., & Van Alstyne, M. W. (2006). Strategies for two-sided markets. Harvard business review, 84(10), 92.*

72. *Eisenmann, T. R., Parker, G. G., & Van Alstyne, M. W. (2011). Platform Envelopment. Strategic Management Journal, 32, 1270-1285.*

73. *Evans, D. S. (2003). Some empirical aspects of multi-sided platform industries. Review of Network Economics, 2(3).*

74. *Fernandez, A. S., Le Roy, F., & Gnyawali, D. R. (2014). Sources and management of tension in co-opetition case evidence from telecommunications satellites manufacturing in Europe. Industrial Marketing Management, 43(2), 222-235.*

75. *Ferrier, W. J. (2001). Navigating the competitive landscape: The drivers and consequences of competitive aggressiveness. Academy of management journal, 44(4), 858-877.*

76. *Fleming, L., & Waguespack, D. M. (2007). Brokerage, Boundary Spanning, and Leadership in Open Innovation Communities. Organization Science, 18(2), 165-180.*

77. *Gal, U., Lyytinen, K. & Yoo, Y. (2008). The Dynamics of IT Boundary Objects, Information Infrastructures, and Organisational Identities: The Introduction of 3D Modelling Technologies into the Architecture, Engineering, and Construction Industry. European Journal of Information Systems, 17, pp. 290-304.*

78. *Garud, R., Jain, S., & Kumaraswamy, A. (2002). Institutional entrepreneurship in the sponsorship of common technological standards: The case of Sun Microsystems and Java. Academy of management journal, 45(1), 196-214.*

79. *Garud, R., Jain, S., & Kumaraswamy, A. (2002). "Institutional Entrepreneurship in the Sponsorship of Common Technological Standards: The Case of Sun Microsystems and Java". Academy of Management Journal, 45 (1), pp. 196-214.*

80. *Gawer, A., & Cusumano, M. A. (2002). Platform leadership: How Intel, Microsoft, and Cisco drive industry innovation (pp. 29-30). Boston: Harvard Business School Press.*

81. *Gawer, A. (2014). Bridging Different Perspectives on Technological Platforms: Towards an Integrated Framework. Research Policy, 43(7), 1239-1249.*

82. *Gawer, A., & Cusumano, M. A. (2008). How companies become platform leaders. MIT Sloan management review, 49(2), 28.*

83. *Gibson, J. J. (1979). The Ecological Appraoch to Visual Perception. Boston: Houghton Mifflin.*

84. *Ghazawneh, A., & Henfridsson, O. (2013). Balancing platform control and external contribution in third‐party development: the boundary resources model. Information Systems Journal, 23(2), 173-192.*

85. *Glaser, B. G. (1963). Retreading research materials: The use of secondary analysis by the independent researcher. The American Behavioral Scientist, 6(10), 11.*

86. *Gnyawali, D. R., & Park, B. J. R. (2009). Co‐opetition and technological innovation in small and medium‐sized enterprises: A multilevel conceptual model. Journal of small business management, 47(3), 308-330.*

87. *Gogan, J. L. (2005). Punctuation and Path Dependence: Examining a Vertical IT Standard-Setting Process. Electronic Markets, 15 (4), pp. 344-354.*

88. *Golder, P. (2000). Historical method in marketing research with new evidence on long-term market share stability. Journal of Marketing Research, 37(2), 156-172.*

89. *Granovetter, M. S. (1973). The strength of weak ties. American journal of sociology, 78(6), 1360-1380.*

90. *Gregory, R. W., Beck, R., & Keil, M. (2013). Control Balancing in Information Systems Development Offshoring Projects. Mis Quarterly, 37(4), 1211-1232.*

91. *Grigg, S. (1991). Archival practice and the foundations of historical method. The Journal of American History, 78(1), 228-239.*

92. *Grindley, P. (1995). Standards, Strategy, and Policy: Cases and Stories. Oxford University Press, New York.*

93. *Grisot, M., Hanseth, O., & Thorseng, A. A. (2014). Innovation of, in, on infrastructures: articulating the role of architecture in information infrastructure evolution. Journal of the Association for Information Systems, 15(4), 197- 219.*

94. *Grover, V., & Kohli, R. (2012). Cocreating IT value: New capabilities and metrics for multifirm environments. MIS Quarterly, 36(1).*

95. *Grøtnes, E. (2009). Standardization as open innovation: two cases from the mobile industry. Information Technology & People, 22(4), 367-381.*

96. *Gu, T., Pung, H. K., & Zhang, D. Q. (2004). Toward an OSGi-based infrastructure for context-aware applications. Pervasive Computing, IEEE, 3(4), 66-74.*

97. *Hagiu, A., & Wright, J. (2015). Multi-sided platforms. International Journal of Industrial Organization, 43, 162-174.*

98. *Hanseth, O., Jacucci, E., Grisot, M., & Aanestad, M. (2006). Reflexive standardization: side effects and complexity in standard making. MIS Quarterly, 563-581.*

99. *Hanseth, O. & Monteiro, E. (1997). Inscribing Behavior in Information Infrastructure Standards. Accounting, Management & Information Technology, 7 (4), pp. 183-211.*

100. *Haraway, Donna (1991). Simians, cyborgs, and women: The reinvention of nature. New York: Routledge.*

101. *Hargrave, T. J., & Van de Ven, A. H. (2006). A collective action model of institutional innovation. Academy of management review, 31(4), 864-888.*

102. *Heaton, J. (2004). Reworking qualitative data. Sage.*

103. *Heaton, J. (2008). Secondary analysis of qualitative data: An overview. Historical Social Research/Historische Sozialforschung, 33-45.*

104. *Henfridsson, O., & Bygstad, B. (2013). The generative mechanisms of digital infrastructure evolution. MIS quarterly, 37(3).*

105. *Henfridsson, O., & Lindgren, R. (2005). Multi-contextuality in ubiquitous computing: Investigating the car case through action research. Information and Organization, 15(2), 95-124.*

106. *Hepsø, V., Monteiro, E. & Rolland, K. H. (2009). "Ecologies for e-Infrastructures". Journal of the Association for Information Systems, 10 (Special Issue), pp. 430-446.*

107. *Hoffmann, W., Lavie, D., Reuer, J. J., & Shipilov, A. (2014). The Interplay of Competition and Cooperation. Strategic Management Journal, Call for paper for a special issue.*

108. *Howell, M., & Prevenier, W. (2001). From reliable sources—An introduction to historical methods. Ithaca: Cornell University Press.*

109. *Imbrex and tegula. (n.d.). In Wikipedia. Retrieved August 2, 2017, from https://en.wikipedia.org/wiki/Imbrex_and_tegula*

110. *Ingram, P. & Yue, L. Q. (2008). Structure, Affect and Identity as Bases of Organizational Competition and Cooperation. The Academy of Management Annals, 2(1), 275-303.*

111. *Introna, L. D., & Hayes, N. (2011). On Sociomaterial Imbrications: What Plagiarism Detection Systems Reveal and Why it Matters. Information & Organization, 21(3), 107-122.*

112. Jones, M. (2014). A Matter of Life and Death: Exploring Conceptualizations of Sociomateriality in the Context of Critical Care. Mis Quarterly, 38(3).

113. Koch, T. & Windsperger, J. (2017). Seeing through the Network: Competitive Advantage in the Digital Economy. Journal of Organization Design, 6(6), 1-30.

114. Lado, A. A., Boyd, N. G., & Hanlon, S. C. (1997). Competition, cooperation, and the search for economic rents: a syncretic model. Academy of Management Review, 22(1), 110-141.

115. Langlois, R. N. (2002). Modularity in technology and organization. Journal of economic behavior & organization, 49(1), 19-37.

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

117. Latham, E. R., & Sassen, S. (2005). Digital formations: Constructing an object of study. In in R. Latham and S Sassen (Eds), Digital Formations: IT and New Architecture in the Global Realm. Princeton.

118. Larsson, R., Bengtsson, L., Henriksson, K. and Sparks, J. (1999), Barriers to interorganizational learning: developing collective knowledge across corporate boundaries, Advances in Management Cognition and Organizational Information, Vol. 6, pp. 115-47.

119. Latour, B. (2005). Reassembling the social: An introduction to actor-network-theory. Oxford university press.

120. Lee, C., Nordstedt, D., & Helal, S. (2003). Enabling smart spaces with OSGi. Pervasive Computing, IEEE, 2(3), 89-94.

121. Lee, A. S., & Baskerville, R. L. (2003). Generalizing generalizability in information systems research. Information Systems Research, 14(3), 221-243.

122. Le Masson, P., Weil, B., & Hatchuel, A. (2011). Platforms for the Design of Platforms: Collaborating in the Unknown. In A. Gawer (Ed.), Platforms, markets and innovation. (pp. 237-299). Cheltenham, UK: Edward Elgar Publishing.

123. Leiponen, A. E. (2008). Competing Through Cooperation: The Organization of Standard Setting in Wireless Telecommunications. Management Science, 54(11), 1904-1919.

124. Leonardi, P. M. (2010). Digital materiality? How artifacts without matter, matter. First monday, 15(6).

125. Leonardi, P. M. (2011). When Flexible Routines Meet Flexible Technologies: Affordances, Constraints, and the Imbrication of Human and Material Agencies MIS Quarterly, 35(1), 147-167.

126. Leonardi, P. M. (2012). Materiality, sociomateriality, and socio-technical systems: what do these terms mean? How are they related? Do we need them? In P. M. Leonardi, B. A. Nardi, & J. Kallinikos (Eds.), Materiality and Organizing: Social Interaction in a Technological World (pp. 25-48). Oxford: Oxford University Press, 2012.

127. Leonardi, P. M. (2013). Theoretical foundations for the study of sociomateriality. *Information and Organization, 23(2), 59-76.*

128. Lewis, M. W. (2000). Exploring paradox: Toward a more comprehensive guide. *Academy of Management review, 25(4), 760-776.*

129. Li, D., & Ferreira, M. P. (2008). Partner selection for international strategic alliances in emerging economies. *Scandinavian Journal of Management, 24(4), 308-319.*

130. Lindgren, R., Andersson, M., & Henfridsson, O. (2008). Multi-Contextuality in Boundary-Spanning Practices. *Information Systems Journal, 18, pp. 641-661.*

131. Lindgren, R., Henfridsson, O., & Schultze, U. (2004). Design Principles for Competence Management Systems: A Synthesis of an Action Research Study. *MIS Quarterly, 28 (3), pp. 435-472.*

132. Loebbecke, C., Thomas, B., & Ullrich, T. (2012). Assessing Cloud readiness at Continental AG. *MIS Quarterly Executive, 11(1).*

133. Luo, Y. (2007). A coopetition perspective of global competition. *Journal of world business, 42(2), 129-144.*

134. Luo, X., Rindfleisch, A., & Tse, D. K. (2007). Working with rivals: The impact of competitor alliances on financial performance. *Journal of marketing research, 44(1), 73-83.*

135. Lyytinen, K., & Yoo, Y. (2002). Research commentary: the next wave of nomadic computing. *Information systems research, 13(4), 377-388.*

136. Lyytinen, K., & Newman, M. (2008). Explaining Information Systems Change: A Punctuated Socio-Technical Change Model. *European Journal of Information Systems, 17, 589-613*

137. Malhotra, A., Gosain, S., & El Sawy, O. (2007). Leveraging Standard Electronic Business Interfaces to Enable Adaptive Supply Chain Partnerships. *Information Systems Research, 18 (3), pp. 260-279.*

138. Mantena, R., & Saha, R. L. (2012). Co-opetition between differentiated platforms in two-sided markets. *Journal of Management Information Systems, 29(2), 109-140.*

139. Marsden, P. V., & Campbell, K. E. (1984). Measuring tie strength. *Social forces, 63(2), 482-501.*

140. Markus, L. M., Steinfield, C. W., Wigand, R. T., & Minton, G. (2006). Industry-Wide Information Systems Standardization as Collective Action: The Case of the U.S. Residential Mortgage Industry. *MIS Quarterly, 30(Special Issue), 439-465.*

141. Markus, M. L., & Loebbecke, C. (2013). Commoditized digital processes and business community platforms: new opportunities and challenges for digital business strategies. *Mis Quarterly, 37(2), 649-654.*

142. Marwick, A. (2001). The new nature of history—knowledge, evidence, language. *Chicago, IL: Lyceum Books.*

143. Mason, R. O., McKenney, J. L., & Copeland, D. G. (1997a). Developing an historical tradition in MIS research. *MIS quarterly, 21(3), 257-278.*

144. *Mason, R. O., McKenney, J. L., & Copeland, D. G. (1997b). An historical method for MIS research: Steps and assumptions. MIS Quarterly, 21(3), 307-320.*

145. *Mathiassen, L. (2002). Collaborative Practice Research. Information Technology & People, 15 (4), pp. 321-345.*

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

147. *McKay, K., & Marshall, P. (2001). The Dual Imperatives of Action Research. Information Technology & People, 14 (1), pp. 46-59.*

148. *McKenney, J. L., Mason, R. O., & Copeland, D. G. (1997). Bank of America: The crest and trough of technological leadership. MIS Quarterly, 21(3), 321-353.*

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

150. *Munslow, A. (1997). Deconstructing history. New York: Routledge.*

151. *Mutch, A. (2013). Sociomateriality—Taking the wrong turning?. Information and Organization, 23(1), 28-40.*

152. *Myers, M. D. (1997). Qualitative research in information systems. Management Information Systems Quarterly, 21(2), 241-242.*

153. *Nalebuff, B., Brandenburger, A., & Maulana, A. (1996). Co-opetition. London: HarperCollinsBusiness.*

154. *Nalebuff, B. J., & Brandenburger, A. M. (1997). Co-opetition: Competitive and cooperative business strategies for the digital economy. Strategy & Leadership, 25(6), 28–33.*

155. *Nambisan, S., Lyytinen, K., Majchrzak, A., & Song, M. (2017). Digital Innovation Management: Reinventing Innovation Management Research In a Digital World. MIS Quarterly, 41(1).*

156. *Narayanan, V. K., & Chen, T. (2012). Research on technology standards: Accomplishment and challenges. Research Policy, 41(8), 1375-1406.*

157. *Oinas-Kukkonen, H., & Oinas-Kukkonen, H. (2014). What every information systems (IS) researcher should know about IS history (ISH) research.*

158. *Orlikowski, W. J., & Baroudi, J. J. (1991). Studying information technology in organizations: Research approaches and assumptions. Information systems research, 2(1), 1-28.*

159. *Orlikowski, W. J. (2000). Using Technology and Constituting Structures: A Practice Lens for Studying Technology in Organizations. Organization Science, 11(4), 404-428.*

160. *Orlikowski, W. J. (2007). Sociomaterial Practices: Exploring Technology at Work. Organization Studies, 28, 1435-1448.*

161. *Orlikowski, W. J., & Scott, S. V. (2008). Sociomateriality: Challenging the Separation of Technology, Work and Organization. Annals of the Academy of Management, 2(1), 433-474.*

162. *Oshri, I., & Weeber, C. (2006). Cooperation and competition standards-setting activities in the digitization era: The case of wireless information devices. Technology Analysis & Strategic Management, 18(2), 265-283.*

163. *Park, B. J. R., Srivastava, M. K., & Gnyawali, D. R. (2014). Walking the tight rope of coopetition: Impact of competition and cooperation intensities and balance on firm innovation performance. Industrial Marketing Management, 43(2), 210-221.*
164. *Parker, G. G., & Van Alstyne, M. W. (2005). Two-Sided Network Effects: A Theory of Information Product Design Management Science, 51(10), 1494-1504.*
165. *Parker, G., Van Alstyne, M., & Jiang, X. (2017). Platform Ecosystems: How Developers Invert the Firm. MIS Quarterly, 41(1), 255-266.*
166. *Pickering, A. (1995). The mangle of practice: Time, agency, and science., Chicago, University of Chicago Press.*
167. *Pipek, V., & Wulf, V. (2009). Infrastructuring: Towards an Integrated Perspective on the Design and Use of Information Technology. Journal of the Association for Information Systems, 10 (Special Issue), pp. 447-473.*
168. *Porac, J. F., Thomas, H., Wilson, F., Paton, D., & Kanfer, A. (1995). Rivalry and the industry model of Scottish knitwear producers. Administrative Science Quarterly, 203-227.*
169. *Porch, C., Timbrell, G., & Rosemann, M. (2015, May). Platforms: A Systematic Review Of The Literature Using Algorithmic Historiography. In ECIS.*
170. *Porra, J., Hirschheim, R., & Parks, M. S. (2005). The History of Texaco's Corporate Information Technology Function: A General Systems Theoretical Interpretation. MIS Quarterly, 29(4), 721–746.*
171. *Porra, J., Hirschheim, R., & Parks, M. S. (2014). The historical research method and information systems research. Journal of the Association for Information Systems, 15(9), 536.*
172. *Ranerup, A. (2012). The socio-material pragmatics of e-governance mobilization. Government Information Quarterly, 29(3), 413-423.*
173. *Reillier, L. C., & Reillier, B. (2017). Platform Strategy: How to Unlock the Power of Communities and Networks to Grow Your Business. Taylor & Francis.*
174. *Reimers, K., & Li, M. (2005). Antecedents of a Transaction Cost Theory of Vertical IS Standardization Processes. Electronic Markets, 15 (4), pp. 301-312.*
175. *Ritala, P., Golnam, A., & Wegmann, A. (2014). Coopetition-based business models: The case of Amazon. com. Industrial Marketing Management, 43(2), 236-249.*
176. *Rochet, J. C., & Tirole, J. (2003). Platform competition in two-sided markets. Journal of the european economic association, 1(4), 990-1029.*
177. *Roehl, T. W., & Truittf, J. F. (1987). Stormy open marriages are better: Evidence from US, Japanese and French cooperative ventures in commercial aircraft. Columbia Journal World Business, 22(2): 87-95.*
178. *Rysman, M., & Simcoe, T. (2008). Patent and the Performance of Voluntary Standard-Setting Organizations. Management Science, 54(11), 1920-1934.*
179. *Sahay, S., Monteiro, E. & Annestad, M. (2009). Configurable Politics and Asymmetric Integration: Health e-Infrastructures in India. Journal of the Association for Information Systems, 10 (Special Issue), pp. 399-414.*

180. Sahaym, A., Steensma, H. K., & Schilling, M. A. (2007). The influence of information technology on the use of loosely coupled organizational forms: An industry-level analysis. Organization Science, 18(5), 865-880.

181. Saadatmand, F., & Lindgren, R. (2016, January). The Tension between Stabilized Cooperation and Intensified Competition: Greening of Technological Frames in Practice. In 2016 49th Hawaii International Conference on System Sciences (HICSS) (pp. 327-336). IEEE.

182. Saadatmand, F., Lindgren, R., & Schultze, U. (2017). Evolving Shared Platforms: An Imbrication Lens. In 2017 International Conference on Information Systems (ICIS) proceeding.

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

184. Sassen, S. (2002). Towards a sociology of information technology. Current Sociology, 50(3), 365-388.

185. Schilling, M. A. (2000). Toward a general modular systems theory and its application to interfirm product modularity. Academy of management review, 25(2), 312-334.

186. Schilling, M. A. (2009). Protecting or diffusing a technology platform: tradeoffs in appropriability, network externalities, and architectural control. Chapters.

187. Schultze, U., & Orlikowski, W. J. (2004). A practice perspective on technology-mediated network relations: The use of Internet-based self-serve technologies. Information Systems Research, 15(1), 87-106.

188. Schultze, U., & Avital, M. (2011). Designing interviews to generate rich data for information systems research. Information and Organization, 21(1), 1-16.

189. Simon, K. A. (2000). From Control to Drift: The Dynamics of Corporate Information Infrastructures. Oxford University Press, Oxford.

190. Smith, R., & Lux, D. (1993). Historical method in consumer research: Developing causal explanations of change. Journal of Consumer Research, 19(4), 595-610.

191. Stabell, C. B., & Fjeldstad, Ø. D. (1998). Configuring value for competitive advantage: on chains, shops, and networks. Strategic Management Journal, 413-437.

192. Star, S. L., & Ruhleder, K. (1996). Steps Toward an Ecology of Infrastructure: Design and Access for Large Information Spaces. Information Systems Research, 7 (1), pp. 111-134.

193. Steinfield, C., Markus, M. L., & Wigand, R. T. (2011). Through a glass clearly: standards, architecture, and process transparency in

global supply chains. *Journal of Management Information Systems, 28(2), 75-108.*

194. Suarez, F. F., & Utterback, J. M. (1995). Dominant designs and the survival of firms. *Strategic management journal, 16(6), 415-430.*

195. Suarez, F. F. (2004). Battles for technological dominance: an integrative framework. *Research Policy, 33(2), 271-286.*

196. Suchman, L. (2007). Human-machine reconfigurations: Plans and situated actions. *Cambridge University Press.*

197. Sun, H. (2013). A Longitudinal Study of Herd Behavior in the Adoption and Continued Use of Technology. *MIS Quarterly, 37(4), 1013-1041.*

198. Sun, R., Gregor, S., & Keating, B. (2015). Information Technology Platforms: Conceptualisation and a Review of Emerging Research in the IS Discipline. In *The 26th Australasian Conference on Information Systems, At Adelaide.*

199. Tan, B., Pan, S. L., Lu, X., & Huang, L. (2015). The role of IS capabilities in the development of multi-sided platforms: The digital ecosystem strategy of Alibaba. Com. *Journal of the Association for Information Systems, 16(4), 248.*

200. Taylor, J. R., Groleau, C., Heaton, L., & Van Every, E. 2001. *The Computerization of Work: A Communication Perspective, Thousand Oaks, CA: Sage Publications.*

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

202. Teece, D. J. (1998). Capturing value from knowledge assets: The new economy, markets for know-how, and intangible assets. *California management review, 40(3), 55-79.*

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

204. Tegarden, L. F., Hatfield, D. E., & Echols, A. E. (1999). Doomed from the start: What is the value of selecting a future dominant design?. *Strategic Management Journal, 495-518.*

205. Thomas, L. D., Autio, E., & Gann, D. M. (2014). Architectural leverage: putting platforms in context. *The Academy of Management Perspectives, 28(2), 198-219.*

206. Tilson, D., Lyytinen, K., & Sørensen, C. (2010). Digital Infrastructures: The Missing Research Agenda. *Information Systems Research, 21 (4), pp. 748-759.*

207. Tiwana, A., Konsynski, B., & Bush, A. A. (2010). Research commentary-Platform evolution: Coevolution of platform architecture, governance, and environmental dynamics. *Information Systems Research, 21(4), 675-687.*

208. Tiwana, A. (2015). Evolutionary Competition in Platform Ecosystems. *Information Systems Research.*

209. *Top 100 most valuable global brands (2017) Milliward Brown Retrieved from http://www.millwardbrown.com/brandz/top-global-brands/2017 (visited on January 28, 2018)*

210. *Treem, J.W. & Leonardi, P.M. (2012). Social Media Use in Organizations: Exploring the Affordances of Visibility, Editability, Persistence, and Association. Communication Yearbook, 36, 143-189.*

211. *Tsai, W. (2002). Social structure of "coopetition" within a multiunit organization: Coordination, competition, and intraorganizational knowledge sharing. Organization science, 13(2), 179-190.*

212. *Tuchman, B. (1981). Practicing history. NY: Alfred Knopf.*

213. *Ure, J., Hartswood, M., Wardlaw, J., Procter, R., Anderson, S., Gonzales-Veles, H., Lin, Y-W., Lloyd, S. & Ho, K. (2009). The Development of Data Infrastructures for eHealth: A Socio-Technical Perspective. Journal of the Association for Information Systems, 10 (Special Issue), pp. 415-429.*

214. *Uzzi, B. (1996). The sources and consequences of embeddedness for the economic performance of organizations: The network effect. American sociological review, 674-698.*

215. *Venkatesh, V., & Brown, S. A. (2001). A longitudinal investigation of personal computers in homes: adoption determinants and emerging challenges. MIS quarterly, 71-102.*

216. *Von Hippel, E. (1987). Cooperation between rivals: Informal know-how trading. Research policy, 16(6), 291-302.*

217. *Volkoff, O., Strong, D. M., & Elmes, M. B. (2007). Technological embeddedness and organizational change. Organization Science, 18(5), 832-848.*

218. *Walley, K. (2007). Coopetition: an introduction to the subject and an agenda for research. International Studies of Management & Organization, 37(2), 11-31.*

219. *Walsham, G. (1995). Interpretive case studies in IS research: nature and method. European Journal of information systems, 4(2), 74-81.*

220. *Wareham, J., Rai, A., & Pickering, G. (2005). Standardization in Vertical Industries: An Institutional Analysis of XML-Based Standards Infusion in Electricity Markets. Electronic Markets, 15(4), 323-334.*

221. *Wareham, J., Fox, P. B., & Giner, J. L. C. (2014). Technology Ecosystem Governance. Organization Science, 25(4), 1195-1215.*

222. *Webster, J. (1998). Desktop videoconferencing: experiences of complete users, wary users, and non-users. MIS Quarterly, 257-286.*

223. *Weiss, M. and Cargill, C. F. (1992). Consortia in the Standards Development Process. Journal of the American Society for Information Science, 43 (8), pp. 559-565.*

224. *Weitzel, T., Beimborn, D., & König, W. (2006). A unified economic model of standard diffusion: the impact of standardization cost, network effects, and network topology. Mis Quarterly, 489-514.*

143

225. *Wigand, R. T., Markus, L. M., & Steinfield, C. W. (2005a).Vertical Industry Information Technology Standards and Standardization. Electronic Markets, 15 (4), pp. 285-288.*
226. *Wigand, R. T., Steinfield, C. W., & Markus, L. M. (2005b). Information Technology Standards Choices and Industry Structure Outcomes: The Case of the U.S. Home Mortgage Industry. Journal of Management Information Systems, 22 (2), pp. 165-191.*
227. *Yates, J., & Murphy, C. (2014). The Role of Firms in Industrial Standards Setting: Virtue and Vice. Paper presented at the The Business History Conference, Frankfurt, Germany.*
228. *Yoo, Y., Lyytinen, K., & Yang, H. (2005). The Role of Standards in Innovation and Diffusion of Broadband Mobile Services: The Case of South Korea. Journal of Strategic Information Systems, 14, pp. 323-353.*
229. *Yoo, Y., Boland, R. J., Lyytinen, K., & Majchrzak, A. (2012). Organizing for Innovation in the Digitized World. Organization Science, 23(5), 1398-1408.*
230. *Zhao, K., Xia, M., & Shaw, M. J. (2007). An Integrated Model of Consortium-Based E-Business Standardization: Collaborative Development and Adoption with Network Externalities. Journal of Management Information Systems, 23(4), 247-271.*
231. *Zhao, K., Xia, M., & Shaw, M. J. (2011). What Motivates Firms to Contribute to Consortium-Based E-Business Standardization. Journal of Management Information Systems, 28(2), 305-334.*
232. *Zhao, K., Xia, M. X., & Shaw, M. J. (2005). Vertical E-Business Standards and Standards Developing Organizations: A Conceptual Framework. Electronic Markets, 15 (4), pp. 289-300.*
233. *Zhu, F., & Furr, N. (2016). Products to Platfroms: Making the Leap. Harvard Business Review, 94(4), 73-78.*
234. *Zhang, D., Wang, X. H., & Hackbarth, K. (2004). OSGi based service infrastructure for context aware automotive telematics. In Proceedings of the IEEE 59th vehicular technology conference, May (Vol. 5, pp. 2957-2961).*
235. *Zittrain, J. L. (2006). The generative internet. Harvard Law Review, 1974-2040.*

APPENDIX

1. Coopetition concepts

Concept	Definition	References	Exemplary quotes
Hostility	Hostility is characterized by the perceptions a firm holds of another firm; is it a partner, a "good" competitor, or an enemy. Therefore it is very prestigious to win over a competitor when hostility is high.	Bengtsson et al. 2010 Baldwin and Bengtsson, 2004 Easton, 1990	*"What [Vehco] did was actually bad installations... they were piggybacking on the CAN. It made the CAN network function improperly and in some cases this even caused accidents. We didn't see this as a major problem, but still you don't want someone else to play with the nerves in your heart." (Global telematics manager at Volvo Trucks, , April 25, 2016)*
Symmetry	Symmetry occurs when competitors operate in the same product and market segments, while using the same resources .The degree of symmetry or similarity can vary, however, as firms can offer different products to the same market and so forth.	Bengtsson et al. 2010 Chen, 1996	*High symmetry between Volvo and Scania both because of manufacturing of trucks and because of the software system both manufacturers produce (Researchers of Viktoria Institute, Analysis of Telematics system in the Swedish market, March 28, 2003).*
Intensity	Intensity surfaces when frequent moves and countermoves occurs between competitors. When intensity is high competitors are affected by moves made by others.	Bengtsson et al. 2010 Ferrier, 2001 Chen et al., 2007 Porac et al., 1995 Easton and Araujo, 1992	*"Vendor representatives have to avoid selling their stuff at these [workshop] occasions...As moderators you need to find ways to get rid of such unwanted behavior. When I discuss functionality I should do it without tying specific features to the participating vendors."(Sales manager at Locus Scandinavia, November 28, 2002)*
Trust	Trust is the necessary element in cooperative relationships to encourage sharing of information, and resources. High degrees of trust, therefore, aid innovation and continuous cooperation.	Bengtsson et al. 2010 Larsson et al., 1999 Uzzi, 1996 Li and Ferreira, 2008	*"Vehco will never get into that OSGi from an OEM perspective... simply because then they've to become a tier one supplier. It's still Volvo that has the responsibility for completing the service solution and they're just a software company."(Global telematics manager at Volvo Trucks, April 25, 2016)*
Tie strength	Tie strength shows the interaction patterns between competitors. High tie strength signals a cooperative relationship. Variables such as closeness, frequency of contact, and common projects represents high tie strength.	Bengtsson et al. 2010 Granovetter, 1973 Marsden and Campbell, 1984	*"We looked into FMS very early [when it was released] in all brands: Iveco, Mercedes, Scania, and Volvo. But we got concerned about the errors it had especially in displaying fuel consumption... [Now] we have collaboration with Drivec... [a company that] takes the data directly from the CAN-BUS." (Managing director at Transics, March 10, 2004)*
Complement-arity	Complementarity between partners stems from resource complementarity. A complementary inter-partner resource alignment is present when dissimilar resources are contributed and these resources are fully performing for the achievement of alliance goals.	Bengtsson et al. 2010 Das and Teng, 2003	*"Since Vehco does not work with order-handling system, the goal is that the solution gets connected to commercial systems that exist on the market e.g., Hogia's transport planning system... The PDA in the truck is used for handling orders, and at the same time to save the [embedded] parameters for automatic cost-tracking e.g., fuel consumption." (managing director of Vehco, , September 6, 2004)*

2. Coopetition dynamics through three phases of MSI

Phase → / Relation ↓	OSGi: Jan 2002 to April 2004	WS: May 2004 to Dec 2009	BPM: Jan 2010 to June 2016
Truck manufacturer - ERP provider	Volvo Trucks-Hogia *Cooperation (High complementarity; Low trust, Low tie strength) Weak* *Competition(Low Symmetry, High Intensity, Low hostility) Weak*	Volvo Trucks-Hogia *Cooperation (High complementarity; Low trust, Low Tie strength) Weak* *Competition(Low symmetry, High Intensity, High Hostility) Moderate*	Volvo Trucks-Hogia *Cooperation (Low complementarity; Low trust, Low tie strength) Weak* *Competition (Low symmetry, High intensity, Low hostility) Weak*
Truck manufacturer - Vehicle Telematics	Volvo Trucks-Vehco *Cooperation (High Complementarity; Low trust, Low tie strength) Weak* *Competition (High symmetry, High intensity, High hostility) Strong*	Volvo Trucks-Vehco *Cooperation (High Complementarity; Low trust, Low tie strength) Weak* *Competition (High symmetry, High intensity, Low hostility) Moderate*	Volvo Trucks-Vehco *Cooperation (High Complementarity; Low trust, Low tie strength) Weak* *Competition (Low symmetry, High intensity, Low hostility) Weak*
Truck manufacturer - Mobile technologies provider	Volvo Trucks-Transits *Cooperation (High complementarity; Low trust, Low tie strength) Weak* *Competition (Low symmetry, High intensity, High hostility) Moderate*	Volvo Trucks-MobiOne *Cooperation (High complementarity; High trust, Low tie strength) Moderate* *Competition (Low symmetry, High intensity, Low hostility) Weak*	Volvo Trucks-DPS *Cooperation (High complementarity; High trust, Low tie strength) Moderate* *Competition (High symmetry, High intensity, High hostility) Strong*
Truck manufacturer - Truck manufacturer	Volvo Trucks-Scania *Cooperation (Low complementarity; High trust, High tie strength) Moderate* *Competition (High symmetry, High intensity, Low hostility) Moderate*	Volvo Trucks-Scania *Cooperation (Low complementarity; High trust, High tie strength) Moderate* *Competition (High symmetry, High intensity, Low hostility) Moderate*	Volvo Trucks-Scania *Cooperation (Low Complementarity; High Trust, High Tie strength) Moderate* *Competition (High symmetry, High intensity, Low hostility) Moderate*
ERP provider - ERP provider	Hogia-NL Partner *Cooperation (Low complementarity; High trust, Low tie strength) Weak* *Competition (High symmetry, High intensity, low hostility) Moderate*	Hogia-NL Partner *Cooperation (High complementarity; High trust, Low tie strength) Moderate* *Competition (High symmetry, High intensity, High hostility) Strong*	Hogia-Locus *Cooperation (Low complementarity; High trust, Low tie strength) Weak* *Competition (High symmetry, High intensity, High hostility) Strong*

3. Interface conformability concepts

Criterion	Definition	Examples in MSI

Clearly Specified	Functions and parameters have self-explanatory, consistent names.	In the interface in phase II (WebServices) one of the parameter types is defined as below:
		
		``xml
		<xsd:complexType name="myEqDataCategoryStringType">
		  <xsd:simpleContent>
		    <xsd:restriction base="msi:EqDataCategoryStringType">
		      <xsd:enumeration value="axle_load"/>
		      <xsd:enumeration value="temperature"/>
		    </xsd:restriction>
		  </xsd:simpleContent>
		</xsd:complexType>
		``
		
		However neither myEqDataCategoryStringType nor the axle_load are self-explanatory names.

Unambiguous	Related concepts are named unambiguously. It should be easy to associate the names with the right concepts without looking them up in the documentation.	In the code below which is a part of the interface of phase II, it is difficult not to confuse the relation between the CommunicationParticipatorType, and comParticipatorCategory.
		
		``xml
		<xs:complexType name="CommunicationParticipatorType">
		  <xs:sequence>
		    <xs:element name="address" type="xs:string">
		    </xs:element>
		    <xs:element name="comParticipatorCategory"
		    type="msi:ComParticipatorCategoryStringType">
		    </xs:element>
		``

Well-documented	A well-documented interface must have: 1) datatypes specs, 2) function specs, and 3) an introduction document that binds the whole into a logical entity.	Interface in phase II had very abstract documentation of parameters, e.g. the explanation below on sender and receiver does not explain does not give enough information to the developer: *Sender and receiver are both CommunicationParticipators. It is important to note that it is intended to describe human and non-human actors alike. They contain a communication address string, a descriptor of the type of actor, e.g. system type or worker designation, the role of the participator (types yet undecided but meant to describe basic information such as e.g. the e-mail "cc"), and an optional name.*
Stable	The object model is adaptable to future changes including removing data types, renaming them, or removing properties.	In update documentation of the interface in phase II, changes mostly concern name changing, type changing, and removing of parameters. While update documentation of the interface in phase III are less frequent and mostly consist of adding parameters rather than removing.
Standardized	An interface that allow different technologies to work together, regardless of language or platform.	In phase I the interface worked only with an OSGi infrastructure and each vendor required its own specifically tailored interface while the interface in phase II worked with different technologies and vendor modules.

Gothenburg Studies in Informatics

1. Ulf Sundin. A Logic Programming Approach to Information Modelling and Database Design, May 1990. (Licentiate Thesis).

2. Thanos Magolas and Kalevi Pessi. En studie om informationssystems-arkitekturer (in Swedish), February 1991. (Licentiate Thesis).

3. Peter Nordenstam. Individbaserade relativt öppna informationssystem (in Swedish), February, 1990. (Licentiate Thesis).

4. Bo Dahlbom and Lars Mathiassen. Struggling with quality; The Philosophy of Developing Computer Systems, August 1991. (Revised edition: Computers in Context. The Philosophy and Practice of Systems Design, Oxford: Blackwell, 1993.)

5. Börje Langefors. Essays on infology. Summing up and Planning for the Future, Edited by Bo Dahlbom, August 1993.

6. Bo Dahlbom (ed.). The Infological Equation. Essays in honor of Börje Langefors, March 1995.

7. Bo Dahlbom, Frederik Kämmerer, Fredrik Ljungberg, Jan Stage and Carsten Sørensen (eds.). Designing in Context. Proceedings of the 18th Information Systems Research Seminar in Scandinavia, June 1995.

8. Bo Dahlbom, Fredrik Ljungberg, Urban Nuldén, Kai Simon, Jan Stage and Carsten Sørensen (eds.). The Future. Proceedings of the 19th Information Systems Research Seminar in Scandinavia, June 1996.

9. Agneta Ranerup. Användarmedverkan med representanter (in Swedish), August 1996. (Doctoral Thesis).

10. Ole Hanseth. Information Technology as Infrastructure, November 1996. (Doctoral Thesis).

11. Fredrik Ljungberg. Networking, September 1997. (Doctoral Thesis).

12. Jan Ljungberg. From Workflow to Conversation, October 1997. (Doctoral Thesis).

13. Thanos Magoulas and Kalevi Pessi. Strategisk IT-management (in Swedish), March 1998. (Doctoral Thesis).

14. Fredrik Ljungberg (ed.). Informatics in the Next Millennium. Essays in honor of Bo Dahlbom, June 1999.

15. Urban Nuldén. e-ducation, May 1999. (Doctoral Thesis).

16. Lars Erik Holmquist. Breaking the Screen Barrier, May 2000. (Doctoral Thesis).

17. Nina Lundberg. IT in Healthcare - Artifacts, Infrastructures and Medical Practices, May 2000. (Doctoral Thesis).

18. Henrik Fagrell. Mobile Knowledge, October 2000. (Doctoral Thesis).

19. Staffan Björk. Flip Zooming - The Development of an Information Visualization Technique, October 2000. (Doctoral Thesis).

20. Johan Redström. Designing Everyday Computational Things, May 2001. (Doctoral Thesis).

21. Dick Stenmark. Designing the new Intranet, March 2002. (Doctoral Thesis).

22. Pouya Pourkomeylian. Software Practice Improvement, March 2002. (Doctoral Thesis).

23. Rikard Lindgren. Competence Systems, June 2002. (Doctoral Thesis).

24. Ulrika Lundh Snis. Codifying Knowledge, October 2002. (Doctoral Thesis).

25. Lars Svensson. Communities of Distance Education, December 2002. (Doctoral Thesis).

26. Kai Simon. BPR in the Pharmaceutical Industry, April 2003. (Doctoral Thesis).

27. Per Dahlberg. Local Mobility, May 2003. (Doctoral Thesis).

28. Alexandra Weilenmann. Doing Mobility, June 2003. (Doctoral Thesis).

29. Carina Ihlström. The Evolution of a New(s) Genre, September 2004. (Doctoral Thesis).

30. Antonio Cordella. Information Infrastructures in Action, November 2004. (Doctoral Thesis).

31. Helena Holmström. Community-Based Customer Involvement for Improving Packaged Software Development, November 2004. (Doctoral Thesis).

32. Christian Hardless. Designing Competence Development Systems, March 2005. (Doctoral Thesis).

33. Andreas Nilsson. Sport Informatics – Exploring IT Support for Spectators at Sporting Events, November 2005. (Doctoral Thesis).

34. Johan Lundin. Talking about Work – Designing Information Technology for Learning in Interaction, November 2005. (Doctoral Thesis).

35. Agneta Nilsson. Contextual Implementation of Organizational Networking Systems, August 2006. (Doctoral Thesis).

36. Mathias Klang. Disruptive Technology – Effects of Technology Regulation on Democracy, October 2006. (Doctoral Thesis).

37. Ulrika Josefsson. Coping Online – Patients' Use of the Internet, February 2007. (Doctoral Thesis).

38. Magnus Holmqvist. Developing And Implementing IS/IT in Aftermarket Logistics, June 2007. (Doctoral Thesis).

39. Jonas Landgren. Designing information Technology For Emergency Response, September 2007. (Doctoral Thesis).

40. Magnus Andersson. Heterogeneous IT Innovation. Developing industrial architectural knowledge, October 2007. (Doctoral Thesis).

41. Nicklas Lundblad. Law in a Noise Society, February 2008. (Doctoral Thesis).

42. Maria Åkesson. Digital Innovation in the value networks of newspapers, September 2009. (Doctoral Thesis).

43. Marie Eneman. Developing Effective Child Protection Strategies: Critical Study of Offenders' Use of Information Technology for Sexual Exploitation of Children, December 2010. (Doctoral Thesis).

44. Elisabeth Frisk. Evaluating as Designing, March 2011. (Doctoral Thesis).

45. Ann Svensson. Kunskapsintegrering med informationssystem i professions orienterade praktiker (cover paper in Swedish), May 2012. (Doctoral Thesis).

46. Maria Bolin. Narrativer i förändringsarbete – från projekt till Athenas plan. September 2014.

47. Tomas Lindroth. Being Multisituated – Characterizing Laptoping in Networked Situations, April 2015.

48. Wanda Presthus. Business Intelligence Utilisation through Bootstrapping and Adaptation, September 2015. (Doctoral Thesis).

49. Jesper Lund. Digital Innovation: Orchestrating Network Activities. September 2015. (Doctoral Thesis).

50. Soumitra Chowdhury. Service Logic in Digitalized Product Platforms – A Study of digital service innovation in the Vehicle Industry. September 2015. (Doctoral Thesis).

51. Fatemeh Saadatmand. Shared Platform Evolution: An Imbrication Analysis of Coopetition and Architecture. March 2018. (Doctoral Thesis).