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Digitizing Products Towards Platforms: The Case of Vehicle Motion System

Completed Research Paper

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Abstract

The development of digital product platforms is a prevailing trend in many industries. As firms incorporate digital technologies into established product categories, they need to manage tensions on multiple organizational layers including strategy, technology and structure. Recent findings suggest that tensions are most likely to be managed by creating resource and coordination flexibility. This paper reports a longitudinal case study of developing a digital product platform. By drawing on organizational ambidexterity theory, we identify four mechanisms—re-scripting, centralizing, redirecting and decoupling—through which the firm creates resource and coordination flexibility. The resulting resource and coordination flexibility in turn lead to the transformation of the firm's strategy, technology and internal structure. The contribution of this study is in adopting an internal perspective and a bottom-up approach which help to theorize the evolution of digitized products into digital product platforms in an emergent way.

Keywords: Digital product platforms, digital transformation, organizational ambidexterity, autonomous cars

Introduction

Understanding the organizing for developing digitized products is of great interest to scholars and practitioners (Yoo 2012; Lyytinen et al. 2018; de Reuver et al. 2018). Today, firms are increasingly integrating digital components (e.g., software) into physical product environments (e.g., cars) to tap into new avenues for value creation (e.g., self-driving cars) (Yoo et al. 2012; Hukal and Henfridsson 2018). To leverage the integrative capacity of digital technologies, firms continuously tune and dynamically reconfigure technical and organizational resources towards certain goals (Sandberg et al. 2020). This is a challenging task, however, since existing resources together with accumulated knowledge bases are catered towards existing products that are characterized by stable revenue prospects or market boundaries (March 1991; O'Reilly and Tushman 2013). The tuning of organizational resources is thus accompanied by transforming the "old" towards the "new" (Gregory et al. 2019; Venkatraman 2017).

To illustrate, most car manufactures have been equipping their vehicles with automatic functionalities to assist drivers during their journey. Automatic functionalities present an industry standard for almost newly produced premium vehicles and have been accordingly institutionalized within organizational boundaries with dedicated resources and teams. A promising market segment such as Mobility-as-a-Service (i.e., MaaS) on the other hand, is considered to be a risky business venture. While entering the MaaS market may create novel use cases such as on-demand autonomous transportation, it requires substantial organizational resources and capabilities in areas including the development of autonomous vehicles, the operation of highly responsive real-time platform architectures, and the safe management of third-party software. Thus, the aforementioned digital innovations (Yoo et al. 2010) for producing new market offerings (Nambisan et al. 2017) are likely to cause transformative changes (Sandberg et al. 2020) in different organizational layers such as *strategy*, *technology*, and operational *structures* (Gregory et al. 2019).

That being said, such transformation and its translation at the operational level within organizations (e.g., managing competences, work processes or product evolution) is still in many ways an understudied area. Prior research has provided useful insights into how digital innovation leads to the emergence of "new" products, services, business models, and organizing rationale (e.g., Henfridsson and Bygstad 2013). However, digital innovation in incumbent firms is not limited to the emergence of the "new"; it also includes the challenges of transforming the "old". The study by Svahn et al. (2017), for instance, uncovered multiple tension points the Swedish car manufacturer, Volvo, faced while transforming traditional cars into a platform for connected car services (i.e., digital product platforms). Specifically, the study illustrates various internal and external struggles or "concerns" in areas such as innovation capability, governance, and collaboration. However, the way the shift from traditional cars to connected car services was managed at the operational level, or whether the technological changes had fundamentally transformed internal structures have remained opaque in the aforementioned study.

This is however an important organizational aspect to understand since these fundamental changes in various organizational layers enable firms to dynamically and continuously respond to drastic market or technological changes to ensure their long-term survival (O'Reilly and Tushman 2008). In other words, theorizing how or whether organizing digital innovation leads to digital transformation is a worthwhile research inquiry (Gregory et al. 2019). Similarly, from an operational viewpoint, prior studies have generally suggested that as firms integrate digital components into physical products, they transition from an internal production-oriented logic to an external supply-chain innovation organizing logic (Thomas et al. 2014; Sandberg et al. 2020). Yet, how such changes in one layer, (e.g., *technology*) causes ripple effects in other layers (e.g., *strategy* or internal firm *structures*), has received limited attention (Sandberg et al. 2020; Gregory et al. 2019). Understanding the interconnection of these layers is important for identifying the drivers and trajectories of digital transformation and better managing its emergent and contingent nature (Staykova 2018; Warner and Wäger 2019). To understand how digital transformation occurs and how it could be managed in various organizational layers, we propose the following research question:

How does digital transformation unfold as firms digitize products towards digital product platforms?

To account for how the organizing towards digital innovation leads to digital transformation within firms' interrelated organizational layers (e.g., *strategy*, *technology*, and *structure*), we have analyzed the case of the Swedish car manufacturer, NEVS, as it decided to enter the promising market of mobility services. During our study, NEVS was facing considerable market uncertainties (i.e., strategy layer), while continuously re-organizing its self-driving technology (i.e., *technology layer*) and work teams (i.e., *structure layer*) towards achieving its MaaS vision. Through longitudinal first-hand observations we a) detail the tensions between existing and new requisite strategies, technologies and structures, b) analyze how NEVS balanced these tension points, and c) and explain how these tensions lead to transformations within NEVS' organizational layers. By studying tension points in organizational layers that are caused by digital innovations, we employ and contribute to the literature on organizational ambidexterity (O'Reilly and Tushman 2013). Organizational ambidexterity provides a suitable theoretical frame to understand the tension and balancing logic within organizations when the "old" is facing the "new" on its path towards organizational equilibria. In this study, the old (i.e., automatic function of a car) with reliable revenue prospects and market boundaries is in tension with a new and unproven market segment (i.e., MaaS) that require balancing mechanisms in the aforementioned organizational layers.

The rest of the paper is organized as follows. In the next section, we explain how the digitization of products leads to tensions within organizational layers. The section is followed by an account of organizational ambidexterity as an appropriate lens for studying those tensions and efforts towards achieving organizational equilibria. We then describe the research setting and approach, and present the results, which are subsequently discussed. The paper ends by implications and suggestions for future research.

Balancing Digital Innovation

Studying how firms manage the digitization of physical products into digital product platforms presents a suitable setting for theorizing the relationship between digital innovation and digital transformation. Today, ubiquitous computing and modularity, as well as the availability of cheaper, smaller, and more powerful technologies have changed nearly all aspects of firms' in how they create and deliver value (Gregory 2019; Sørensen 2018; Tilson et al. 2010; Yoo et al. 2010). With flexible and cost-effective component reconfigurations, digitized products can be easily repurposed for new emerging uses cases (Yoo, 2012). As firms embed digital components into physical product environments, these digitized products become hybrids or digital product platforms, characterized with agnostic functionalities with third parties that may exceed the original product use case (Yoo et al. 2010). The latter is synonymous with innovation or business networks, and if successful, its revenues may exceed the revenues of physical products they are built on. That being said, the prevailing trend of digitized products, however, poses several challenges, particularly for traditional orientated firms on different organizational layers.

Take business strategies as an example. Business strategies relying on tightly and vertically integrated value chain economies are particularly difficult to replace with new and promising ones like digitized products for innovation networks, as these types of economies differ in their value creation logic (Gregory et al. 2019; Stabell and Fjeldstad 1998). Transformation of business strategies is particularly demanding for pre-digital industries such as the automotive industry. Piccinini et al. (2015) reveal in their study how IT-enabled business transformations bring about tensions between accommodating the short lifecycle of digital technology innovations (e.g., business agility), while trying to accommodate the long lifecycle of industrial product innovations (e.g., business stability). The authors also posit the need to *balance* the contentious relationship between short-term digital technology investments and the investments in long-term digital capabilities for fast-changing markets. These problems get arguably amplified when firms pursue digital innovations in the realm of digital product platforms combined with new market entry ambitions (e.g., MaaS). Besides business strategies, the study by Svahn et al. (2017) suggests that the combination of digital and physical components in most cases results in architectural innovations for existing product categories, which in turn transforms existing knowledge bases. Similarly, being able to respond to fast-changing market dynamics calls for capabilities within organizational boundaries such as tuning work structures that can respond to the aforementioned market dynamics in the first place (e.g. Mohagheghzadeh and Svahn 2016). This is particularly difficult for firms with well-established work divisions, routines, and institutionalized knowledge bases, which support their past decision makings (Winter et al. 2014; Gregory et al. 2019).

Overall, the above-mentioned studies convey two central issues related to digital transformation; first, digitizing products suggests constant balancing activities in various organizational layers, such as *strategy* (e.g. product versus platform), *technology* (e.g., product architecture), and *structure* (e.g., work teams). In their call for theorizing the crossroad between digital innovation and digital transformation, Gregory et al. (2019) similarly identify three overarching organizational layers, namely, *strategy*, *technology*, and *structure* and emphasize that these layers are in constant negotiations with each other in achieving balances. In this study, we argue that digital transformation can be considered as a multi-layered organizational phenomenon where transformation in one layer may causes ripple effects in other layers and vice versa. Second, since transformation in one layer can trigger changes in other layers, digital transformation is also an emergent phenomenon (Gregory et al. 2019; Staykova 2018). Thus, there is a need for a holistic view that not only identifies multiple triggers of digital transformation but also reflects the need for organizing digital innovations in a dynamic and contingent way.

The importance of balancing such tensions as firms engage in innovative undertakings has been studied in the organizational ambidexterity literature. Prior studies on digital product platforms (e.g. Svahn et al. 2017) have similarly suggested to adopt an organizational ambidexterity lens for uncovering the logic or mechanisms for balancing tensions around digital innovation within the same organization. In the same vein, employing organizational ambidexterity in this study as our analytical lens is highly appropriate. New digital product platform owners like car manufacturers continue to serve their existing markets (i.e., selling premium cars with automatic functionalities), and hence, behave exploitatively. At the same time, the very same car manufacturers explore new markets and technologies (i.e., autonomous cars for the MaaS economy) within the same organizational boundaries. Therefore, we posit that digital product platform owners have inherently the potential to be ambidextrous organizations. Additionally, employing organizational ambidexterity as the analytical lens is appropriate with the specific aim of this study, i.e. theorizing how managing digital innovation results in organizational transformation. This is because ambidexterity is not simply about how firms manage or balance tensions as they engage in innovation (O'Reilly & Tushman, 2008). Rather, the sine qua non of organizational ambidexterity is the firm's long-term survival by purposefully and fundamentally transforming its resource and knowledge bases (Helfat, et al., 2007; O'Reilly & Tushman, 2008; O'Reilly & Tushman 2013).

Organizational Ambidexterity: Resource and Coordination Flexibility

A central premise of organizational ambidexterity is the relationship between the exploration of new possibilities and the exploitation of old certainties (March 1991). Studies suggest that a firm's engagement in the exploitation of established paths usually occurs at the expense of exploring new ones. Similarly, an overemphasis on exploration for new products at the exclusion of exploiting old ones may result in high experimentation costs, leaving many undeveloped ideas unused (March 1991). In this context, organizational ambidexterity refers to firms' ability to resolve tensions between processes of exploration and exploitation in fast-changing environments (O'Reilly and Tushman 2013). Overall, the relationship between exploration and exploitation has been seen through three overarching perspectives. Summarizing the extant literature on organizational ambidexterity, Wei et al. (2014) refer to these perspectives as *incompatible*, *interactive*, and *relational* views.

Based on the *incompatible view*, exploration and exploitation are considered to be incompatible processes leading to organizational tensions as both compete for scarce resources and require different organizational capabilities (Wei et al. 2014; Papachroni et al. 2015; Koryak et al. 2017). Based on this view, then, firms need to have separate episodes or departments dedicated to exploitation and exploration. The *interactive view*, on the contrary, sees exploitation and exploration as potentially complementary forces. A high degree of exploitative effort, for instance, can act as the absorptive capacity to generate a greater pool of complementary resources, which in turn improves a firm's effectiveness in exploring new areas (Katila and Ahuja 2002; Cao et al. 2009; Wei et al. 2014). Firms can thus simultaneously engage in exploration and exploitation. However, Wei et al. (2014) argue that both perspectives offer little insight into how firms can organize their socio-technical configurations for sustained competitive advantage. The solution, they argue, lies in the *relational view*. From the *relational view*, rather than focusing on the scarcity of resources that dominates the *incompatible view*, firms need to focus on the dynamic management of their resources. Lacking a dynamic path in managing resources would even neutralize the complementary effects of having a greater resource pool, as promoted by the *interactive view* (Wei et al. 2014).

Forming and testing various hypotheses based on the synthesis of prior studies, Wei et al. statistically demonstrate how two particular forms of dynamic resource management contribute to enhanced organizational ambidexterity. These two forms include creating *resource flexibility* and *coordination flexibility*. The authors define *resource flexibility* as the capabilities to accumulate flexible resources with multiple uses, and *coordination flexibility* as the capabilities to create new resource combinations through new internal coordination processes (Wei et al. 2014). Thus, exploitation and exploration are concluded as neither incompatible nor complementary in nature; instead, they become dependent on contextual conditions (cf. Benner and Tushman 2003; Junni et al. 2013; Koryak et al. 2017) such as *resource* and *coordination flexibility*.

Valuable lessons about the importance of *resource* and *coordination flexibility* can be derived from Information Systems literature, as well. Digital platforms and digital innovation studies have provided us with ample insights about strategies for managing conflicting concerns to accommodate both existing and prospective organizational resources (Henfridsson and Yoo 2014), understanding competing views on division of innovation labor among suppliers and manufacturers (Lee and Berente 2012), building dynamic capabilities for digital transformation (Warner and Wäger 2019), developing managerial toolkits for evaluating competing innovation strategies (Nylén and Holmström 2015), balancing generativity and infrastructural control (Eaton et al. 2014), or managing the conflict of platform ownership and open source sponsorship (Ghazawneh and Henfridsson 2010).

However, previous IS literature has predominantly focused on issues of resource and coordination flexibility from the management perspective and from an external viewpoint. We propose that transformation does not occur only through top-down strategizing (Leonardi 2020); it is also important to understand how digital transformation unfolds at the operational level (e.g., the team's everyday activities). Thus, in line with the *relational view* on organizational ambidexterity as well as the IS scholarship on digital innovation and platforms, we too emphasize the importance of creating *resource* and *coordination flexibility* for the long-term survival of firms. However, since we see organizational ambidexterity as emergent in the dialectics of top-down and bottom-up activities, we focus on the way *resource* and *coordination flexibility* are achieved eventually in the work of operational teams.

Research Setting

We selected National Electric Vehicle Sweden (NEVS) as our empirical setting. NEVS is a Swedish company with production plants in China and Sweden. In 2012, NEVS acquired the assets of SAAB, a former major Swedish car manufacturer, and continued its legacy in car manufacturing but faced financial challenges with its current product line. In 2016, NEVS shifted its focus from traditional cars with combustion engines to exclusively manufacture electric and autonomous vehicles, a new market segment in the automotive industry characterized by high growth opportunities. To make use of these opportunities, NEVS also revised its business strategy by preparing itself to sell mobility services, including ridesharing, delivery, or any other A-to-B services designed for end-users. This way, despite inheriting considerable know-how in traditional car manufacturing, NEVS has been able to develop its independent profile and knowledge base. This change is also mirrored in their organizational methods and structures to produce these new types of cars, reflecting NEVS' transformation towards a digital-born organization (Chanias 2018; Sebastian 2017).

On its path towards adopting a MaaS business logic, one area of concern was the legacy vehicle motion control system that required a complete and costly overhaul. A vehicle motion system entailed separate electronic units for controlling vehicle motion, such as propulsion, steering, and braking. Provided by a complex chain of suppliers, these electronic units came in separate parts. Each electronic control unit (hereafter ECU) included a hardware box in which the control software was embedded. Besides the need for sourcing a considerable amount of hardware parts and the management of a complex supply chain, the system's performance was not optimal from a technological point of view. The speed of data communication between the hardware parts mentioned above was instead designed for traditional cars, which made them highly unsuitable for safely controlling an autonomous car in the public space. As such, NEVS saw the further need to develop a more software-oriented motion control system.

That being said, the process of developing a software-oriented motion control system in-house was an unexplored field for NEVS, to begin with. While NEVS' MaaS vision was apparent, the way towards re-engineering the internal components for a new software-based motion control system for supporting the new vision was less clear. In what follows, we have illustrated NEVS' exploration of new paths for reshaping the vehicle motion system which first emerged as a nebulous and unproven idea, survived with limited resources, and started to gain more attention and influence within NEVS as a MaaS providing platform. We have studied the work of the IVC team, who were in charge of developing the new motion control system.

Data Collection

Given the exploratory nature of our study, we have followed the work of other researchers in adopting an iterative approach in data collection and analysis (Leonardi and Bailey 2008; Henfridsson and Bygstad 2013). In September 2017, we started our field work at NEVS to acquire an overview of the company's agendas related to the development of autonomous cars and MaaS. We had learned that NEVS was exclusively focused on developing electric and autonomous cars as of 2016 and had gone public with its MaaS concept in July 2017. We thus found it an opportune case to follow the development of connected cars and mobility services as an example of the digitalization of the automotive industry. When we started our field work at NEVS, we did not intend to study the work of the IVC squad ("squad" is NEVS' label for teams). We spent approximately 30 hours of conducting interviews and attending meetings with 15 key figures in software and connectivity divisions, product quality management, legal counsels on autonomous drive, and global project management. Our explorative approach had also directed us towards the work of the IVC squad, time and again.

At first, it was not clear to us how this squad's work was related to the area of connected cars and MaaS. The squad was more involved in the transformation of previously hardware-based vehicle motion units into software-based units (i.e., digitization), rather than the application of digitally connected vehicles for mobility services (i.e., digitalization). As the study unfolded, we eventually discovered that the reformation of vehicle motion could be seen as an infrastructural step in developing mobility services (see Henfridsson and Bygstad, 2013). We eventually came to appreciate the survival of the squad's work—despite the start-up's several financial drawbacks—as a "paradigmatic example" (Henfridsson and Bygstad 2013: p. 914) of digitizing physical products into service providing platforms.

The eight-month ethnographic observation of the IVC squad took place between November 2018 and June 2019; about a year after the initial IVC squad had started experimenting with the new motion control system ideas with only 2-3 members. By the time our observations started, the IVC squad's work had picked up speed and consisted of six members. Joining the group at this time was particularly beneficial as they still had a significant amount of work left, which would give us the opportunity for first-hand observations of their work. More importantly, the squad members would now be able to reflect on parts of their work in retrospect, as well. The observation sessions included at least four complete workdays weekly and one day dedicated to analyzing the data, which guided the research steps in the week after.

The IVC squad consisted of 6 developer engineers (7 counting the former lead software engineer) all seated in the same office area without any partitions dividing them. This spatial arrangement allowed them to engage in conversations constantly to brainstorm, troubleshoot, or discuss work-related issues. The first author who was conducting the observations was seated in the same area as the squad. As there were no partitions dividing the squad members, she could both see and hear them performing their work without interruptions. During the observations, the first author took careful field notes about not only the activities of the squad, and the artifacts they used, but also the topics discussed by the squad members as they engaged in conversations to perform their work. These notes assisted her to pose follow-up questions and explore new topics and areas of the squad's work. Relevant conversations were audio-recorded and subsequently analyzed by the end of each week. The observations thus resembled what Hennink et al. (2010) describe as "watching an unfolding drama unfold with characters, events, and storylines" (p. 170).

We also interviewed each squad member at least twice in two separate interview rounds (see Table 1). In the first round, we focused more on what the squad had been doing during its lifetime and how. In the second round of the interviews, we were particularly focused on understanding the trigger behind activities and initiatives in the squad. In this round, why questions were particularly dominant. For example, "why are you even integrating the ECUs in the first place", "why do you think the way you work is not optimal?", and "why is developing a new control system important now, why has it not happened before?"

	Role	IVC Developer	IVC Developer	IVC Developer	IVC Developer	IVC former Lead SW Engineer	IVC Developer	IVC Lead SW Engineer	Test Simulation Engineer	Head SW Tribe	
Round 1	Date	Nov 2018	Nov 2018	Nov 2018	Nov 2018	Nov 2018	Mar 2019	Apr 2018	Nov 2018	-	Total Hours 10:21
	Hours	01: 22	01:10	01:17	01:33	00:41	01:07	01:03	02:00	-	
Round 2	Date	Apr 2019	May 2019	Jul 2019	Apr 2019	June 2019	May 2019	May/Jun 2019	-	Apr/May 2019	Total Hours 14:07
	Hours	01:02	01:09	01:44	01:11	00:44	01:33	01:57+ 03:06	-	00:48+ 01:32	

Table 1. Interview Rounds

Data Analysis

We first adopted an exploratory approach to data to avoid missing parts that lie outside the scope of the selected analytic lens (Walsham 1995). In this initial round of our data analysis, we tried to identify as many activities and overarching events that characterized the work-life of the IVC squad. However, it is not surprising that eight months of intensive ethnographic fieldwork can provide data for telling a story in multiple directions. A "disciplined pursuit and analysis of the data" (Sarker et al. 2013), thus, required us to adopt a focused or selective round of analysis (Bryman 2012). Guided by our analytical lens, the focused analysis called for both inductively and deductively oriented approaches. These inductive and deductive approaches respectively correspond to two overarching analysis strategies inspired by Henfridsson (2014); 1. Making sequence of events meaningful and 2. Naming and framing.

Making sequence of events meaningful: Based on our analytical lens, the focus was on finding processes enabling *resource* and *coordination flexibility* across the three organizational layers of *strategy*, *technology*, and *structure*. We wanted to find out 1. which of the overarching events and activities identified in the initial round of analysis could be seen as instances of creating *resource* and *coordination flexibility*, and 2. to which organizational layer these events and activities correspond. Additionally, since telling a story requires a causal trajectory that drives the temporal progression of events and activities (Henfridsson 2014), we were specifically sensitive towards establishing an explanation for the *why* of events, activities, and choices. The goal of this deductively oriented approach (Bryman, 2012) was to provide a delimiting framework for telling the story. To implement this plan, we asked four general questions exemplified below:

What do they do?	**What is the Activity?**	**What is the activity an instance of?**	**Why do they do it?**
They form teams that can be dissolved at any point of time	Forming dissolvable teams	Coordination of teams Organizational structure	The fast-changing combination of competences required for delivering projects

Table 2. Identifying Activities and Events Related to the Analytical Lens

This step enabled us to eventually order activities in a sequential way and identify three overarching courses of events across the three organizational layers. After finding the central constituent parts, it was time to explore how these parts formed the overall plot.

Naming and framing: As mentioned previously, we intended to highlight the 'interconnected' and 'emergent' nature of processes for creating resource and coordination flexibility. Here, we tried to 1. identify how events, activities, and layers were "connected" to each other, and 2. indicate how processes gradually form in an emergent way. To analyze the interconnection of the events, activities, and layers, we focused on the commonalities between activities and gave them labels, a process Henfridsson (2014) calls naming. We thought that activities which share central characteristics with each other could be considered as iterations of the same organizing process. This inductively oriented approach enabled us to eventually identify mechanisms through which a set of activities across various organizational layers lead to creating *resource* and *coordination flexibility*. An example of naming the interconnections is as follows:

Activity	**Event**	**Organizational layer**	**Common Point (Mechanisms)**
Open new competence areas in-house	In-house development	Strategy	Creating flexibility in resources and collaboration through **centralizing** external development work
Creating a central architecture for different control units	Modifying software architecture	Technology	Creating flexibility in resources through **centralizing** separate technological units

Table 3. Naming Mechanisms of Creating Resource and Coordination Flexibility

Finally, to analyze the 'emergence' of these mechanisms, we focused on the differences and boundaries which separated the mechanisms and their related activities from each other; a strategy Henfridsson (2014) calls framing. We thought, focusing on the points where mechanisms of creating flexibility change, would inform us on when and why various mechanisms of change emerge. This strategy eventually enabled us to identify the phases through which the mechanisms eventually resulted in *resource* and *coordination flexibility*. An example of framing is as follows:

Activity	Event	Organizational layer	Difference Point (Phases)
Creating a central architecture for different control units	Modifying software architecture	Technology	**First**, flexibility is created in resources by **centralizing** architectural parts
Creating the logic for modularization of the architecture	Modifying software architecture	Technology	**Next**, flexibility is created in resources through **decoupling** architectural parts

Table 4. Framing Phases of Creating Resource and Coordination Flexibility

To check the plausibility of our findings (Henfridsson 2014; Avison and Malaurent 2014), we presented them in three separate official presentation meetings to 1. The head of the entire software department 2. The firm's technical management together with the entire management board in the software department (including the IVC squad's manager), and 3. The IVC squad members. All three groups agreed that not only the findings were truthful to their work, but also the findings told a story that went beyond the perspective of one group, included various perspectives, and that the cumulative story did not contradict any group's perspective. The strong point, as pointed out by the software management board and the IVC squad members, was that the findings captured and provided a mental template of what had been constantly difficult for them to explain in a concrete way in terms of the connection between separate events, their sequence, and their distinction.

Results: NEVS' Integrated Vehicle Control System Initiative

To achieve its goal for becoming a future MaaS provider, NEVS' legacy vehicle motion control system underwent several changes. Some of these changes included reducing the amount of hardware that controls vehicle motion, developing a new powerful and central software component for vehicle control that has replaced prior separated and underperforming control units, designing a flexible architecture for motion software to support future mobility services, building a knowledge base for developing and modifying vehicle motion software in-house, and reducing the dependency on suppliers. In doing so, NEVS has completely transformed the architecture of its legacy vehicle motion control system that reduced supplier dependency and provided the technical foundation for fast and flexible reconfigurations for future projects.

Phase 1: Rethinking Motion for Mobility Service (2016-2017)

By the time NEVS went public with its MaaS plans in 2017, the company's head of software department and its technology strategist had already argued extensively that reinventing mobility without rethinking motion would be a half-hearted job. They reasoned that it was specifically the motion control system, which makes any type of mobility possible in the first place. However, the legacy motion control system stood in stark contrast to NEVS' promoted mobility narrative of being "fast, flexible and customer-centric", as the company's leaders put it. For one thing, various parts of the legacy motion system were developed by different suppliers. Relying on an extremely complex chain of suppliers created internal barriers to become fast and service-oriented (*coordination flexibility*). As the head of the software department exemplified it:

> *To get the brake system supplier to trust the model provided by the steering system supplier, wouldn't work and it's hard to see them wanting to share that kind of information seeing it as part of their intellectual property. So, it left us with no choice. And even if you were to fix a set-up where one supplier would use another supplier's model, then for each and every change you wanted to create in a project, it would be rounds of commercial agreements, a lot of contracts, a lot of negotiations, and it would just slow down the execution. Speed is important. So, we saw the strategic importance of reconfiguring the vehicle motion.*

Apart from the external collaboration speed, the numerous inflexible hardware parts in the legacy motion control system could hardly attract an ecosystem of mobility service providers. For example, the legacy motion control system included separate hardware units that contained the controlling software for various motions of the car. Besides occupying significant space in the vehicle and being slow in exchanging data among separate units, the existing setup of hardware parts was a major hurdle in developing flexible services (*resource flexibility*), as confirmed by the testing and simulation engineer who works closely with the IVC team:

> *A regular mechanical component takes a lot of time and money for development, which causes you to not really make so many variants. In case of software, however, you can just keep adding, removing, or upgrading features. And when things are so dynamic, we should be ready for emerging things.*

Continuous integration and modification of software parts for different mobility services requires more than rethinking the ratio of hardware to software. It also requires the development of dedicated and well attuned teams who are fast in delivering products and services for an increasing number of heterogeneous projects (*coordination flexibility*). The vehicle motion control system, for instance, needs to be made ready for continuous integration and modification in various mobility projects, including autonomous drive services. However, the traditional automotive division of labor with silos of expertise and communication hierarchies could not support fast work iterations or catch up with the increasing number of projects. IVC's senior software engineer exemplified the customary and rigid division of labor as follows:

> *Let's say project A requires four different vehicle motion components. So, you'll have a product manager and then there are individual managers in various organizational departments working with those required components. So, the product manager will tell those department managers what he needs and how they need to handle it. Then department managers assign the work to different engineers in their department. Same will be in all the other departments involved in project A. So, you have the product manager, the department managers, the engineers, or senior engineers, and all that in 4 different departments. It becomes that kind of hierarchy.*

Reshaping the legacy motion control system was hence an infrastructural step in reshaping mobility services. The company now needed to find solutions for re-scripting its external and internal collaboration approaches as well as the arrangement of its technological and human resources.

Phase 2: Launching the Integrated Vehicle Motion Control Initiative (2017-2018)

A more efficient motion control system was initially a part that would fit properly into the bigger vision for MaaS. The replacement of hardware by software for digitally driven and connected vehicles made a lot of sense in general. Just like other car manufacturers, NEVS had started to become more software-oriented for autonomous vehicles starting in 2016. However, to officially dedicate resources to reshaping the entire legacy motion control system required strong motivations, considering the financial constraints NEVS had faced as a start-up so far. The fact that a whole new motion control system was not initiated by the top management also reinforced the dilemmas. Thus, the announcement of NEVS' exclusive focus on electric and autonomous cars later in 2016 provided the grounds for an unwavering commitment to reshaping the legacy motion control systems during 2017 and 2018. The plan was to focus on 1. integrating all the various control units for vehicle motion in one central unit, and 2. to develop the entire system inhouse.

Developing an integrated vehicle control unit (hereafter IVC=the new motion control system) inhouse served multiple strategic goals. An IVC would reduce the use and subsequently cost of hardware parts. More importantly, it would take back control of technological developments and innovations from the suppliers (*resource flexibility*). Despite the outspoken benefits of such a plan, the initiators of IVC project had to prevail over quite strong counterarguments. As one of the IVC developers reminded us:

> *You see, there is already a complete infrastructure developed for having separate control units, a lot of knowledge already exists out there. It makes it easy to build something. So, it's already very cheap; you do not have to put any work or any money into research or something. Having the integrated ECU is an idea. And there are not a lot of companies working with it. With the absent knowledge, it would be difficult for a big corporation to shift their strategy just like that! They can work on it on some experimental vehicles. But still, you won't have the necessary knowledge, you won't have the necessary experience.*

The initiators of the new motion control system (IVC), on the other hand, argued that the in-house development of IVC made sense from multiple perspectives. First, an IVC would be more efficient. Digitizing and centralizing separate motion control parts into a powerful central software would replace underperforming hardware parts. However, a more valuable asset was gaining control of the brain of the vehicle for developing autonomous functionalities and mobility services. They argued that with the need to prepare the vehicle motion to be connected to external sources of command such as remote controllers, or Internet of Things devices, the motion control software needed to be highly modifiable. To rely on suppliers for the modification of the software would be time-consuming and costly. It was thus strategically important to build the competence knowledge in-house and take control of the vehicle motion software in future external projects (*resource* and *coordination flexibility*). These visions were realized in 2018, when having developed a proof of concept of the new motion control system (IVC) placed the company's name on the list of attractive partners in a European ecosystem of autonomous drive (hereafter AD) services. The head of the IVC squad explained the company's role in this project as follows:

> *Our external partner has some goals of demonstrating some autonomous drive functions in this project. And NEVS' part is to deliver an enabler with the interfaces to connect the IVC to the AD functionality. The motion command would be defined by the external partner and the IVC would be the enabler of that command making the car move accordingly. That is essentially the intention for us; to see when we have achieved this enabler. That it works together with other systems.*

Soon the enabling features of IVC would be put to test in many mobility projects of different scopes. IVC was now beginning to exceed its return on investment in the form of efficiency. Not only, but IVC was also going to be an efficient component in developing the company's own AD services. More importantly, however, it was going to be a platform for continuous external development. Now, NEVS' concept of motion not only fitted its concept of mobility, but it had started to gain significance in its own right. In other words, a basic component had gained a life of its own (*resource flexibility*). IVC's former senior software engineer highlighted the extended strategic significance of turning IVC as a component to a flexible resource:

> *NEVS is becoming a software development organization. It's all about creating the pattern; it's about 'how' you're actually going to produce your product. Your approach has to give you some kind of advantage. And why becoming a software development organization? Because you know, almost 75 percent of the component in modern cars is software-based. And if you have a hold on that portion, you basically own that car. It will give the creator a competitive advantage. That is one of the goals for NEVS.*

Such flexibility in technological resources, however, had to be supported by the company's human resources and internal operations. To develop a new motion control system, NEVS had to open new competence areas that were traditionally non-existent in-house. This required more human competences being employed and brought together in-house as well. In September 2018, one year of planning for forming an Agile enterprise (referring to the organizational approaches defined in the Agile software manifesto) resulted in a full reorganization of the company's internal arrangements. The reorganization entailed several courses of activities.

First, the old silos of knowledge and divisions of labor were dissolved. A total of four tribes (company's name for major operational departments) now formed the company's operational side. The idea was to emphasize what brought people together in the same center rather than what divided them into separate divisions with hopes of smoother communication and therefore operations (*coordination flexibility*). Second, within each tribe— rather than creating rigid subdivisions and permanently allocating a fixed array of human competences to them—a pool of human resources with diverse relevant competences was created. These employees had no fixed appointments to any teams. Depending on the required competences for each project, an average of five developers with various competence backgrounds would be assigned in a team to work on a project deliverable *(resource flexibility*). Third, all the engineering developers involved in the actual development work within the same tribe were centered in the same physical area at the company, away from managers. Similarly, the managers had their own spatial center.

Thus, as the new motion control system (IVC) was turning into a flexible platform for mobility services, the internal structures were also being reconfigured towards more flexibility. However, to conclude that NEVS had its resource and collaboration flexibility all figured out is a misconstruction.

Phase 3: Reflecting on the Increasing Complexities of IVC Work (2018-2019)

Halfway into IVC's development work, NEVS was receiving collaboration offers to provide the vehicle motion as a platform for testing and development of autonomous drive algorithms by external partners. In addition to external projects, various internal projects also required IVC for testing autonomous functionalities. For all of these projects, the IVC squad needed to modify the architecture of IVC and redesign their work processes. The managers were quite pleased with the development. The squad members, however, were increasingly feeling the strain to realign their work and incorporate IVC in quite fast iterations for several parallel internal and external projects. Apart from the increasing workload, the team collaboration approach was another trigger for dissatisfaction. The Agile framework emphasized the direct allocation of a team to projects rather than dividing the work among several departments. This approach had resulted in grouping engineers from considerably different competence backgrounds in a team. The management strongly believed that these multi-competent teams would increase collaboration flexibility:

> *In the old organizational way, there would be a component owner. So, now, for developing an ECU, should the component owner be a person with primarily software competence or hardware competence while you need both? That is the thing! But, in this Agile mindset, a component would not be owned by an individual; it will be owned by a team with both hardware and software competences, because you need both to specify the requirements of an ECU in a good way.*

The multi-competent teams also believed to be beneficial in creating *resource flexibility*. The Agile framework emphasized a horizontal competence development rather than a vertical competence development. That is, rather than continually working within a specific competence area and gaining deep expertise, team members could expand their competence across several areas by collaborating with and learning from their team members in fulfilling project requirements. Such an Agile approach to competence development would create *resource flexibility* from multiple perspectives, the head of the software tribe contended:

> *The Agile mindset emphasizes that you should step out of your comfort zone, and really grab tasks, and widen your knowledge. That means people will grow in multiple areas. They might not become the 'experts' in all of them, but they will grow. And it also has the added benefit of creating human competence redundancy on the company level. Unlike the old organizational form where if one expert suddenly left the organization or team, the work would come to a halt. Because then no mindset or force had pushed other individuals to learn about each other's expertise so they could cover for one another.*

However, as the architecture of the IVC was starting to become more complex, team members needed to apply deeper field expertise. It was eventually becoming impossible to understand other team members' perspectives (*coordination flexibility*), let alone learning from them. Responding to a soaring number of internal and external projects which incorporated the IVC as a platform, was no help either. They believed both the increasing complexity of the IVC architecture and the number of IVC related projects were becoming incompatible with the goal of the Agile framework for collaboration and competence development. Being pushed to work with people with quite different backgrounds while responding to several projects now seemed more unsystematic rather than agile, as one IVC developer put it:

> *I don't think the horizontal development is the 'point' with Agile teams; I think that's how it's 'happening'. Because, I think, it's only in our team maybe where you get this sort of horizontal development. I don't think in every other team, which is practicing the Agile framework, you get this horizontal development. It is coming out of events, and not out of what it's supposed to do.*

As the IVC architecture was becoming more complex, the Agile framework needed to accommodate more complex work situations. The IVC developers contended that IVC was not only becoming a complex component in supporting NEVS's mobility services, but it was also evolving into a platform for future development work. These two existing sides of IVC needed to be taken into consideration and the Agile framework needed to be adapted to the IVC work to balance out the created tensions. However, the bright side with the Agile framework was the feedback sessions where employees could reflect on the challenges of their work in retrospect. In these sessions, the team members could discuss the distinctive and particular conditions for developing the new vehicle motion. These retrospective sessions would then provide the foundation to solve problematic cases iteratively. The reached solutions rendered a new version of the Agile framework which fitted the specific conditions of working with IVC and at the same time complying with the overall company's Agile framework.

Phase 4: Resolving the Increasing Complexities of IVC Work (2019)

As the IVC software continued to expand and become an integral part of various projects, proper design guidelines and software architecture needed to be defined. This meant a change in the focus of the team from vehicle dynamics to software development standards. However, neither the work guidelines nor the arrangement of competences in the IVC squad accommodated this emerging requirement. Design guidelines and software architecture were mostly missing. The written IVC software was not efficient in terms of performance and memory usage. The entire focus had so far been only on the integration of control software rather than how IVC should be implemented as an efficient software. Part of the problem was expected as much of the IVC squad's work concentrated on R&D. A larger part of the problem nevertheless was due to the company's emphasis on aligning work processes according to the Agile framework rather than following the standard ways of developing software, believed the squad's lead software engineer:

> *Any software engineer knows this is not how you write software. See, everybody in this team wrote the IVC software, but they don't have a background in software engineering. Just because we are in the same team doesn't mean we can do the same thing. Anyways, that wasn't making sense. The scope of the initial IVC architecture was so little that everybody could just do each other's work and then implement it in the software the best way a person from vehicle dynamics could, thinking let's get this up and running. But now, if you want to actually create a production ready software, you need to put a hundred different things into consideration, and then you need people with software backgrounds. Then, not everybody can just do the other's work, as the Agile framework insists.*

Thus, although the company's organizing approach as a whole insisted on the Agile framework, the IVC developers argued that the specific conditions of developing IVC was to be taken into consideration. To reconcile the two, the IVC developers and software tribe managers concluded, important decouplings were to be made both in the IVC architecture and the team structure.

To begin with, the IVC architecture needed to be modularized. Modularization entailed defining the boundaries between a set of constituting elements on various layers of the IVC architecture such as the network or the application layer. The separation of these parts within and across the architectural layers was important for two reasons. First, as a production ready software, the dependency among IVC's architectural parts needed to be reduced (*resource flexibility*). This would allow the integrated vehicle motion platform to offer more flexibility for future development work. More importantly, defining boundaries between modules would become a reliable criterion for forming teams once the number of recruited IVC developers increased. That is, teams of 5-7 members would be allocated to work with a set of similar modules (referring, for instance, to autonomous drive functions on the application layer):

> *Now you need so many people working on different parts. To give them enough flexibility so that they can work on their own part independent of the other's, the boundaries between these parts should be clearly defined. And then the model [architecture] should be defined like that, too. So that they don't have to worry about the dependency between the part they are developing, and the part other teams are developing. That's why we just need to define the modules across architectural layers.*

This way, rather than project-based teams, module-based teams were to be formed. Module-based teams would still be multi-competent. However, as working with a set of similar modules would call for competences that are more closely related, horizontal competence development would become more manageable for team members (*coordination flexibility*). However, separating focal competence areas and dedicating more resources to them required the recruitment of more developers in-house. Acquiring more human resources needed to be backed by strong motivations from a business strategy point of view. IVC needed to prove potentially to be more than a component in NEVS's future cars with some enabling affordances. It needed to promise potentially distinct business values.

Having defined an initial process for modularization of the IVC architecture, finally, in June 2019, demonstrations of IVC started to open new paths of innovation and business coalitions for NEVS. When Protean, a leading firm in innovating in-wheel-motors, witnessed a demonstration of NEVS's new vehicle motion control system (IVC), they immediately found it as an appropriate platform for developing their own products. Protean, which was already about to be acquired by NEVS, was now more confident about joining NEVS. One of the IVC developers commented on the IVC's journey from being only an idea to a potential source of revenue as follows:

> *IVC was only a few people's idea. No one cared much. For example, when I would attend NEVS' all-people's meeting, IVC was never mentioned as a way of going into the future. So, in those meetings I couldn't really relate with anything. They would mention what a great job, others have done in other projects, but never IVC. Until IVC was not built, it was very hard to get the picture. They need to have a real demonstration. So, for example, last week, I had a demo for the Protean's top management. Although it wasn't the reason why Protean was in that meeting, but, once they saw the demo, all their management were like, 'oh, this is exactly what we need for our cars, please talk to our engineers'.*

Protean could not only use the IVC as a platform for its own innovation of in-wheel-motors, but it could also use the knowledge stack and expertise of the IVC developers (*resource flexibility*). Showcasing the potential for a separate line of innovation for IVC was now reinforcing the motivation for dedicating more resources to its development. Thus, to implement the new solutions, the initial IVC team dissolved in June 2019. Around 20-30 developers were eventually recruited to work with the IVC (until January 2020) in various module-based teams. Thus, the new motion control system (IVC) opened new and unpredictable paths for further innovation and value creation independent of the NEVS' own existing products and services.

Discussion

The case of NEVS vehicle motion system is an extensive example of how managing digital innovation leads to the transformation of organizational *strategies*, *technology* and *structure* in an interconnected and emergent way. A look at the various phases of NEVS' transition reveals that changes on one organizational layer affect and depend on the configurations of other layers. NEVS' case also demonstrates that changes on organizational layers are not simply created through pre-planned and bottom-up management initiatives. Rather, changes are motivated contingently by daily practices of operational teams. The way *resource* and *coordination flexibility* transform NEVS' *strategies*, *technology* and *structure* is detailed below. We have presented NEVS' transformation in the IVC squad's work in four phases or mechanisms. The criterion for distinguishing the boundaries among these phases is the common point which connects and bridges a set of activities in a specific time span:

Re-scripting. In phase 1, we witness a set of activities that are focused on creating *resource* and *coordination flexibility* by rethinking and re-writing 1. The way coordination with suppliers took place, 2. The way the vehicle motion technology was configured, and 3. The way teams and operations were structured to respond to the company's new MaaS vision. What characterizes this phase is a mechanism that prompts the firm to reform its *strategy*, *technology* and *structure*. We call this mechanism that drives the activities in the approximate time span of 2016-2017 <u>*Re-scripting*</u>. The Re-scripting mechanism culminates in seeing the reformation of vehicle motion system as an *infrastructural* step in shaping the firm's mobility visions.

Centralizing. In phase 2 then we can spot a shift in the focus of the activities. In this phase, we witness a set of activities with the goal of creating *resource* and *coordination flexibility* by 1. Opening an inhouse development center for the previously external and distributed work to support a fast business *strategy*, 2. Centralizing the previously separate ECUs in a single unit to create *coordination flexibility* and efficiency in the *technology*, and 3. Bringing together people with different competence backgrounds in a team to create *resource* and *coordination flexibility* in teams. What characterizes this phase is thus a mechanism that turns the firm into a strategic hub, a center for technological innovation and a center for fast operations with little structural blocks. We call this mechanism that drives the activities in the approximate time span of 2017-2018 <u>*Centralizing*</u>. The centralizing mechanism culminates in vehicle motion turning into not just a component in NEVS' final product, but a platform for shaping the company's MaaS vision.

Redirecting. In phase 3, we see the concerns shifting towards evaluating the increasing complexities and finding solutions to compensate for them. In this phase, we witness the squad members' attempts to argue for *resource* and *coordination flexibility* by 1. Paying attention to the increasing number of projects in which IVC plays a strategic role, 2. Responding to the increasing complexities of IVC as it is turning from an R&D concept to a production-ready technology, and 3. Adapting the team structures to the increasing complexity and scope of competences required for developing IVC. What characterizes this phase is thus a mechanism that turns the firm into an alert agent which actively evaluates and redirects its *strategic*, *technological* and *structural* positioning. We call this mechanism that drives the activities in the approximate time span of 2018-2019 *Redirecting*. The Redirecting mechanism culminates in highlighting the specific characteristics of IVC which require working conditions different than the firm's overall *strategic*, *technological* and *structural* directions.

Decoupling. Finally, in phase 4, the activities focus on creating important distinctions from a *strategic*, *technological* and *structural* point of view. To create *resource* and *coordination flexibility*, there is a need to 1. Highlight the distinctive business value related to the new vehicle motion system as opposed to the business values of the firm's MaaS visions, 2. Draw clear boundaries between the modules in the IVC's software architecture and 3. Separate the scope of team competence areas based on the boundaries among software modules and layers. What characterizes this phase is thus a mechanism that enables the firm to have distinctive capabilities by creating loose couplings in its *strategy*, *technology*, and *structure*. We call this mechanism that drives the activities in the approximate time span of 2019 *Decoupling*. The Decoupling mechanism culminates in highlighting IVC as a potentially distinct resource for further innovation and value creation. These mechanisms and their related activities are illustrated in Table 5.

		Mechanisms			
	Events	***Re-scripting***	***Centralizing***	***Redirecting***	***Decoupling***
Strategy	Develop vehicle control units in-house	• Minimize supplier dependency • Minimize communication hierarchy with partners	• Develop in-house practices • Open new competence areas in-house	Balance complexity added by the increased number of projects in which IVC plays a strategic role	Promote separate lines of innovation for mobility and motion
Technology	Modify software architecture	• Minimize the time & speed of communication among components • Minimize the amount of hardware	• Integrate control units for propulsion, steering, and braking. • Create interfaces for connecting vehicle motion to outside sources	Balance the added complexity to the software architecture due to the integration of several units in one architecture	Assigning the degree to which vehicle motion functions could be decomposed in different in/dependent modules
Structure	Re-arrange competence composition	• Minimize task-overload • Minimize communication barriers in multi-competency teams	• Streamline developers spatially • Form multi-competency teams	Balance the complexity added by forming multi-competency teams	• Form dissolvable teams • Dissociate competence areas

Table 5. Mechanisms of Resource and Coordination Flexibility

The above-mentioned mechanisms describe how NEVS achieved *resource* and *coordination flexibility* within its organizational boundaries, which in turn supported NEVS in transitioning from its old business strategy (selling combustion/electric cars) to a modern MaaS provider. A closer look at Table 5 reveals that, the four mechanisms are not always directed at creating alignment and convergence among organizational *strategy*, *technology* and *structure*. It is clear that to re-script organizational *strategy*, there was a need to re-script organizational *structure* as well as its technological domain. However, positive outcomes were not necessarily created through consensus and unity (Robey & Boudreau, 1999). Rather, these four mechanisms sometimes would result in *resource* and *coordination flexibility* and solve tensions by giving rise to divergence points. An example is how the team *structure* at the IVC squad diverged from NEVS' overall Agile framework. A more emblematic example is how the apparently contradictory mechanisms such as "centralizing" and "decoupling" were necessary for creating *resource* and *coordination flexibility*. These divergences show that resource and coordination capability is formed by loose couplings (Lee and Berente 2012; Gregory et al. 2018), both within and across organizational layers. In other words, in this complex interrelation of sociotechnical elements (Winter et al. 2014), pluralistic and potentially contradictory elements coexist (Lee and Berente 2012).

This has implications for how processes of digital innovation are organized. For instance, the dialectics of divergence and convergence imply that predicting the overall formal structure of an organization based on the design of the underlying technical system (mirroring hypothesis) (Sanchez and Mahony 1996) is becoming more and more difficult. As Colfer and Baldwin (2016) emphasize and as the NEVS case demonstrates, "digital technologies make possible new modes of coordination that enable groups to deviate from classical mirroring hypothesis" (p. 710). Consequently, designing and organizing the internal operations of a firm around digital innovation needs to be a dynamic and contingent process.

Emphasizing the interconnected and emergent way NEVS managed *resource* and *coordination flexibility* enables us to theorize digital transformation in terms of dynamic capabilities. Dynamic capabilities are capabilities that determine the speed and degree to which a firm's resources can be aligned with unforeseen environmental changes (Teece 2014). Dynamic capabilities are not tied to any current products or purposes (Teece 2014) and they cannot therefore be predicted and implemented as best practices or paths in a top-down manner by the management. In NEVS' case, for instance, although mobility-as-a-service was the firm's overall top-down strategy, motion-as-a-service was spawned by the firm's technological advancements as an unpredicted strategy that would give the company a competitive advantage.

Theorizing digital transformation in terms of dynamic capabilities is also in alignment with organizational ambidexterity. As mentioned previously, simply managing the tensions between exploitation and exploitation (innovation) does not capture the core of organizational ambidexterity (O'Reilly and Tushman 2013). Instead, organizational ambidexterity is achieved if the firm is able to fundamentally reconfigure and transform its resources to survive in the face of changed market conditions, as it attempts to solve tensions (O'Reilly and Tushman 2008; O'Reilly and Tushman 2013). The changes on various organizational layers enabled NEVS to execute a two-track approach by continuing to optimize its existing technological foundation for vehicle motion systems (i.e., being exploitative), while simultaneously being prepared to serve future MaaS markets (i.e., exploratory). As explained previously, developing the capability to optimize existing and exploring new markets is a key feature of ambidextrous organizations.

Finally, existing digital platform studies have provided insights into the evolution of platforms in collaboration with external partners (Ghazawneh and Henfridsson 2010; Eaton et al. 2015) or in collaboration with end-users and co-creators of value (Skog et al. 2018). We complement this line of research by studying a platform in its preparation phase, i.e., how the platform is initially designed and evolved prior to being ready for external collaboration. This research may exhibit limitations in terms of being a single case study and being applicable in other empirical contexts. Car manufactures operate in a safety sensitive industry context, where firms are subject to stricter regulations for market access, hardware and software requirements, which in turn may impacts the degree and fluidity of innovation and collaboration options. On the other hand, these limitations present future avenues for research for conducting cross case studies in (non) safety sensitive industry contexts to validate or expand on our findings or having an in-depth focus on boundary resource development from an internal organizational perspective.

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