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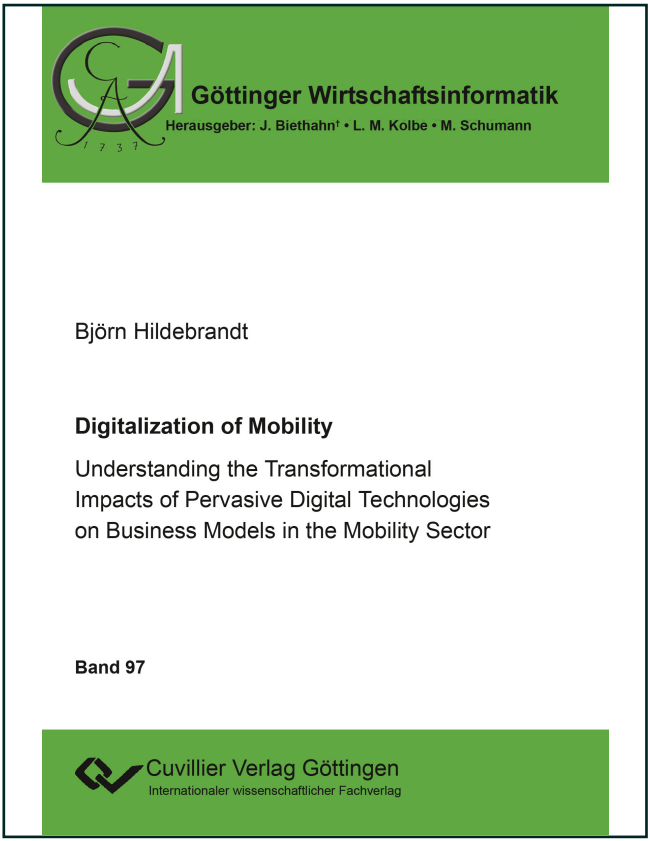
# Digitalization of Mobility

## Understanding the Transformational Impacts of Pervasive Digital Technologies on Business Models in the Mobility Sector

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# I. Introduction

The introductory chapter begins with the motivation for this research (A.I.1), followed by an outline of the research gaps and questions along which this thesis is framed (A.I.2). Afterwards, its basic structure (A.I.3), research context and design (A.I.4), differentiation from prior dissertations at the Chair of Information Management (A.I.5), as well as anticipated contributions for research and practice (A.I.6) are presented.

## I.1 Motivation

In their investigation of twenty-first-century personal urban mobility, Mitchell et al. (2010) state, “For a century, the automobile has offered affordable freedom of movement within cities—the places where most of the world’s people now live, work, play, and pursue their social and cultural lives. It provides access to all of the benefits that cities have to offer; it is an object of desire; and it plays a crucial role in the U.S. and other economies. But it now requires radical reinvention” (p. 1). This far-reaching assertion reflects the major changes that the contemporary mobility landscape is undergoing as it is affected by several mega-trends (Seeger and Bick, 2013). With the mobility sector among the main contributors to environmental degradation (Nykvist and Whitmarsh, 2008; Samaras and Meisterling, 2008), increasing environmental pressure renders it necessary to develop more sustainable technologies (e.g., electric mobility) and alternatives to ownership-based forms of individual mobility (Wells, 2013). This need is further amplified as urbanization and general population growth lead to higher travel demand, inundating contemporary cities with traffic congestion, local $CO_2$ and noise emissions, as well as shortages of parking space (Prettenthaler and Steininger, 1999; Willing et al., 2017). Furthermore, changing societal values – particularly those of the younger generation – and the emergence of the sharing economy (Belk, 2013; Kathan et al., 2016) indicate that the perceived importance of the self-owned private car is decreasing.

Recently, these developments have been accompanied by another major trend affecting economies and societies worldwide: the ongoing diffusion of digital technologies throughout almost all aspects of everyday life (Yoo, 2010). Advances in broadband Internet and the emergence of mobile devices such as smartphones have made information readily accessible, unconstrained by time and space (Junglas and Watson, 2006). Such developments have changed the way people work, communicate and interact with others, and live their lives as a whole, underscoring the socio-technical nature of the digitalization phenomenon (Tilson et al., 2010). The increased presence of digital technologies can be observed not only for consumers but also for suppliers. Incited by ongoing improvements in processing power, gains in storage and power efficiency, the miniaturization of hardware, as well as an unprecedented level of connectivity, firms across virtually every industry have begun to explore the options provided by new digital technologies and to reap their potentials (Matt et al., 2015; Yoo et al., 2010b). In the mobility domain, this phenomenon can be easily seen in automobile manufacturers’ incorporation of digital technologies into their core

products, offering an increasing number of new applications, such as real-time navigation, infotainment systems, driver assistance, and autonomous driving (King and Lyytinen, 2004; Yoo, 2010). Rail companies provide mobile apps for checking departure times and booking tickets and offer wireless Internet access for onboard entertainment. At the same time, there is an expansion of external actors pervading the mobility domain, including leading players from the digital space (e.g., Google, Apple) and numerous startups (e.g., Uber, mytaxi, Drivy, Turo, Lyft). These actors have begun to invent new mobility business models that benefit from the options granted by digital technologies (Remane et al., 2016c).

With more and more individuals participating in the digital revolution and an increasing number of businesses creating and offering digital content, services, or products (Karimi and Walter, 2015) that affect peoples' everyday mobility, the physical mobility infrastructure becomes shrouded by an overarching digital layer (Hanelt et al., 2015b). As a result of the ubiquitous connectivity provided, firms face new forms of communication, interaction, cooperation, and competition, and thus alternate means of value creation and value capture (Bharadwaj et al., 2013). Accordingly, widespread digitalization helps to unearth significant opportunities for reorganizing existing socio-technical arrangements in personal mobility that have existed for decades (Tilson et al., 2010). Prior research has made some progress in investigating the capacity of emergent digital technologies to enable specific forms of disruptive mobility business models, such as carsharing, ride sharing, electric mobility, or intermodal travel (e.g., Cohen and Kietzmann, 2014; Kley et al., 2011; Teubner and Flath, 2015; Willing et al., 2017), which hold the potential to drive a transformative change in the physical mobility system. Moreover, research has focused on examining the paradigmatic shift from physical to digital innovation in the context of incumbent mobility firms (e.g., Hanelt, 2016; Hylving et al., 2012; Piccinini et al., 2015a). While such studies provide valuable insights for specific instances or segments of the mobility domain, there is still a lack of conceptual and empirical findings describing how digital technologies drive transformational change in the socio-technical mobility landscape at large (Yoo et al., 2010b). To date, this phenomenon has predominantly been described in an anecdotal manner (e.g., Porter and Heppelmann, 2014; Yoo, 2010). Furthermore, findings from other sectors whose core value propositions could be displaced by their digital complements – e.g., photography or news gathering (e.g., Karimi and Walter, 2015; Lucas and Goh, 2009) – cannot be applied for the case of personal mobility, which by nature demands a physical core.

Due to its usefulness for studying systemic change processes based on the co-evolution of technology and society (Geels, 2012), this cumulative study employs a multi-level perspective. By doing so, this research seeks to provide an enhanced understanding of (1) the overarching nature of digitalization and its impacts on business models in general terms, (2) changes in incumbent mobility firms' business models in response to the increased diffusion of digital technologies in their primarily physical sectors, and (3) the potentials of digital technologies to improve value creation and capture in disruptive mobility business models.

The business model concept has proven particularly suitable for studying the transformational impacts of digital technologies on the socio-technical mobility landscape due to several reasons. First, as companies commercialize new technologies through their business models (Chesbrough, 2010), they provide a useful lens for investigating the novel opportunities offered by digital technologies. Second, due to its boundary-spanning nature (Zott and Amit, 2010), the business model serves as an intermediating construct that is capable of capturing the interdependencies between a firm and its surrounding environment (Veit et al., 2014). This conceptualization acknowledges not only the importance of social interactions for business but also the necessity of adapting business models in light of changing environmental conditions (Teece, 2010; Veit et al., 2014) – a factor that is becoming increasingly essential in this era of widespread digitalization of businesses and society at large. By investigating how the diffusion of digital technologies changes business models in the mobility domain, this thesis aspires to contribute important implications for information systems (IS) research and business practice.

## I.2 Research Questions

The ongoing diffusion of digital technologies has unleashed fundamental changes in virtually all aspects of society (Lucas et al., 2013; Yoo, 2010), including everyday mobility. Therefore, the goal of this study is to contribute to a better understanding of the transformational impacts of digital technologies on business models in the mobility sector. For that purpose, the study is divided into four fundamental research questions that are outlined in the following.

First, this thesis relates the phenomenon of digitalization to the landscape of mobility in general terms. Prior research has made significant progress in shedding light on the increasingly important role of digital technologies within the mobility domain. For instance, with respect to car-based mobility, the increasing presence of digital technologies has been described as enabling a variety of new applications affecting peoples' everyday mobility, such as navigation, communication and entertainment systems, and driver assistance (Juliussen, 2003; Yoo, 2010). At the same time, digital technologies have been found to facilitate the rise of completely new and disruptive mobility business models, such as diverse forms of shared mobility (Bardhi and Eckhardt, 2012; Cohen and Kietzmann, 2014; Teubner and Flath, 2015). However, a differentiated understanding of the transformational impacts of digitalization on the socio-technical mobility landscape at large remains missing. Insights from other industries whose products and business models have been completely replaced by their digital counterparts (e.g., Karimi and Walter, 2015; Lucas and Goh, 2009) cannot be applied here, as the mobility domain, by nature, relies on physical elements, such as vehicles and the associated infrastructure.

Socio-technical transitions literature has demonstrated the usefulness of applying a multi-level perspective to understanding and explaining the complex dynamics of change processes based on the co-evolution of technology and society – also in the mobility domain (e.g., Geels, 2012). However – despite pervasive technologies and ubiquitous computing

having been identified as instances of so-called landscape developments that affect societies worldwide and determine the exogenous environment in which actors operate – existing studies focus primarily on other major drivers of socio-technical transitions, such as environmental pressure or regulations (Geels, 2012; Geels and Kemp, 2006; Nykvist and Whitmarsh, 2008). Moreover, these studies fail to account for the powerful affordances of digital technologies (Yoo et al., 2010b) and the emergence of digital eco-systems (Corallo et al., 2007) that have been reported to change the roles and rules of relationships amongst organizations, consumers, and other actors in the socio-technical systems in which they emerge (Bharadwaj et al., 2013; El Sawy et al., 2010; El Sawy and Pereira, 2013; Lucas et al., 2013; Yoo et al., 2012). Due to a lack of scientific research in this context, we must learn more about how pervasive digital technologies and emerging digital eco-systems drive the socio-technical transition of the physical mobility system and pave the way for new disruptive business models. By applying a socio-technical lens for investigating the transformational impact of emerging digital technologies on the physical mobility landscape, this study contributes to Yoo et al.'s (2012) call “to embrace more fully the new socio-technical reality of a ubiquitous presence of digital technology in everyday life” (p. 1403). Hence, the first research question is derived as follows:

> *RQ1: How do digital eco-systems promote the socio-technical transition towards future mobility and pave the way for disruptive mobility business models?*

The second section aspires to systematically structure the novel developments based upon digital technologies. As firms’ business models constitute an important part of the socio-technical systems in which they are nested – being closely connected to the surrounding elements, such as infrastructures, actors, and user practices (Bidmon and Knab, 2014) – they become a valuable unit of analysis. However, drawing upon a comprehensive literature review of business models, Veit et al. (2014) point out that this perspective is rarely applied in the field of IS research, despite being well suited for investigating the novel approaches developed in the context of widespread digitalization.

Much of business model research applies a static view to the concept, focusing on fundamentals, such as its definitions, components, or representations (Zott et al., 2011). However, Cavalcante (2013) stresses that “it is not enough merely to identify and describe central components of a firm’s business model. It is also essential to understand the dynamics of a business model, i.e. how a business model changes over time” (p. 287). In line with this argumentation, this study adopts a dynamic view of business models, i.e., business model innovation, rather than considering only a snapshot of the way that firms conduct business. Moreover, prior research has described the changing role of IS in business contexts in the last decades, ranging from computing applications in corporate back offices to IT-enabled business processes and, more recently, moving towards becoming businesses in themselves (e.g., El Sawy and Pereira, 2013). To account for these distinct mechanisms and the variety of technologies captured by the term ‘digital technologies’ (Bharadwaj et al., 2013), this study follows Hanelt (2016) and begins by adopting the broader notion of IS (see Watson et al., 2010) to examine the increasing digitalization of businesses. Despite the

progress made in analyzing the impact of IS on changes in firms' business models for single instances (e.g., Björkdahl, 2009; Desyllas and Sako, 2013) or generally classifying the foci of IS research on business models (e.g., Burkhart et al., 2011), a holistic overview and comprehensive understanding of the distinct roles played by IS in business model innovation is still lacking. Insights from other innovation contexts – such as process, product, or service innovation (e.g., Kleis et al., 2012; Lyytinen and Rose, 2003; Nambisan, 2013) – do not account for the specifics and complexity of the business model concept and therefore cannot be applied here without verification (Amit and Zott, 2012; Fichman et al., 2014; Schneider and Spieth, 2013). This leads to the second research question:

*RQ2: What are the roles of IS in business model innovation?*

As a third major aspect, this study focuses on investigating how incumbent mobility firms react to the increasing diffusion of digital technologies in their socio-technical systems. While competition has been present ever since, the convergent and generative nature of digital technologies has unleashed a new era of competitive struggle – also in primarily physical sectors such as personal mobility – forcing incumbent firms to rethink the ways in which they conduct business (Bharadwaj et al., 2013; Porter and Heppelmann, 2014; Yoo, 2010). To account for customers' changing preferences (Lucas et al., 2013), firms must innovate their business models. The focus on business model innovation, i.e., how business models change over time, is particularly valuable, as several researchers perceive a dearth of literature investigating the dynamics of business models, particularly those of incumbent firms, which are shaped by established structures and other lock-in effects from their still-functioning business models (Cavalcante, 2013; Demil et al., 2015; Sosna et al., 2010).

With a focus on the dominant means of personal mobility (i.e., automobility), prior research has begun to investigate the paradigmatic change from physical to digital innovation by, e.g., describing the design principles and design processes of product-related services (Henfridsson and Lindgren, 2005; Lenfle and Midler, 2009) as well as the product architectures and organization logics associated with the hybridization of physical and digital components (Hylving and Schultze, 2013). Moreover, attention has been paid to the internal tensions (Andreasson et al., 2010; Hylving et al., 2012) and managerial challenges (Hanelt, 2016; Piccinini et al., 2015a) resulting from the contradictory innovation logics of physical and digital components. Karimi and Walter (2015) conclude that such a radical technological change "often creates capability gaps for incumbent firms in the industry because it introduces new technological knowledge and alternatives, new ways of performing organizational activities, and new ways of creating value" (p. 43). On top of this, Piccinini et al.'s (2015a) exploratory Delphi study with 19 automotive experts identified digital business model innovation as one of the most significant managerial challenges associated with digital transformation in the automotive industry. As quantitative insights on automotive incumbents' digital business model innovations and the means by which they source the new and heterogeneous knowledge (Yoo et al., 2012) required for digital innovation remain scarce, this study seeks to explore the third research question:

*RQ3: How does the increased diffusion of digital technologies impact business model innovations of incumbent mobility firms and how do they source the knowledge required for digital innovation?*

Finally, the fourth section focuses on the emergence and diffusion of disruptive mobility business models, as they play a decisive role in socio-technical transitions (Geels, 2012). While disruptive business models rely on the basic assumption that they have the potential to outperform prevailing business models at some time, they typically underperform in established mainstream market attributes upon introduction and therefore occupy only small market niches (Christensen, 1997; Danneels, 2004; Govindarajan and Kopalle, 2006). Accordingly, the question is how to increase the attractiveness of disruptive mobility business models for both consumers and providers. However, despite initial indications that digital technologies could be a substantial vehicle in this regard (e.g., Cohen and Kietzmann, 2014), Baiyere and Salmela (2013) draw on a comprehensive literature review to identify a "lack of research studying the particular role of IT in the occurrence of disruptive innovation" (p. 8).

Recent studies have highlighted significant opportunities provided by widespread digitalization in reorganizing various socio-technical arrangements (Tilson et al., 2010), including personal mobility. For instance, the increased penetration of digital technologies in everyday life (Yoo, 2010) and the emergence of digital eco-systems have been found to enable new disruptive mobility business models that emphasize customer experience as an alternative to ownership (El Sawy and Pereira, 2013). Accordingly, some studies have categorized and described different forms of shared mobility business models (e.g., Cohen and Kietzmann, 2014) or digital mobility business models in general (e.g., Remane et al., 2016a, 2016c). However, research on the perspective of increasing the attractiveness of disruptive mobility business models via digital business model innovation is relatively scarce, with one exception being Bohnsack and Pinkse (2017), who use the concept to describe value proposition reconfiguration tactics for increasing the market acceptance of electric vehicles. Moreover, Desyllas and Sako (2013) conclude, "Although the emergent business model literature has elaborated on the mechanisms for value creation and delivery when new business models are conceived and implemented, it has left the issue of value capture relatively under-explored" (p. 101). To address this gap, a simultaneous focus on both value creation and capture is particularly useful, as these mechanisms refer to two sides of the same coin (Priem et al., 2013). Therefore, as we still know relatively little on how digital technologies alter value creation and capture in disruptive mobility business models, the final research question is formulated as follows:

*RQ4: How do digital technologies improve value creation and capture in disruptive mobility business models?*

## I.3 Structure of the Thesis

This cumulative study is composed of three major parts: Part A elaborates upon the foundations, as mentioned above. Part B, the centerpiece of this work, is structured along the research questions outlined in Section A.I.2 and presents the five research papers constituting this cumulative dissertation. The first chapter (B.I) focuses on the important role of digitalization in the transition towards future mobility. It delivers a conceptual framework along with four theoretical propositions that are delved into in the subsequent sections. Chapter B.II employs a business model perspective to analyze and structure recent approaches that have been shaped by digital technologies. In particular, this chapter aims to investigate the distinct mechanisms through which IS affect changes in firms' business models. Afterwards, Chapter B.III details the impact of pervasive digital technologies on business model innovation of incumbent mobility firms. Finally, Studies 4 and 5 in Chapter B.IV focus on disruptive mobility solutions, using the example of carsharing to establish an analysis of how digital technologies improve value creation and capture in disruptive mobility business models. By doing so, each paper represents a major building block for gaining a profound understanding of the transformational impacts of digital technologies on business models in the mobility sector. Table A-1 presents an overview of each study, including details on the respective publication outlets, research questions addressed, and main contributions.

*Table A-1. Overview of studies constituting the cumulative dissertation*

| No. | Outlet | Status | Ranking (VHB) | Chapter | Core RQ | Main contribution |
|---|---|---|---|---|---|---|
| 1 | China Media Research | Published | n.a. | B.I | 1 | Multi-level framework and theoretical propositions explaining how digital eco-systems (digital technologies, actors, and relationships between them) disrupt and transform established patterns in the mobility sector. |
| 2 | European Conference on Information Systems 2015 | Published | B | B.II | 2 | Taxonomy uncovering the distinct roles of IS in business model innovation as (1) enablers, (2) capabilities, and (3) frames of reference for business model innovation. |
| 3 | International Conference on Information Systems 2015 (Best Paper Nominee) | Published | A | B.III | 3 | Investigation of automotive incumbents' digital business model innovations, their effects on future firm performance, as well as the impact of acquiring external digital knowledge on OEMs' innovativeness. |
| 4 | International Conference on Wirtschaftsinformatik 2015 | Published | C | B. IV | 4 | Evaluation of the role of IS for the perceived attractiveness of disruptive mobility business models by drawing upon the three functions of IS: informate, automate, and transformate. |
| 5 | Business & Information Systems Engineering | Published | B | B.IV | 4 | Insights on the importance of viewing consumers (and other entities) as integral parts of digital business eco-systems by applying the potentials of digital technologies not only for co-creating but also co-capturing value with them. |

Lastly, Part C provides a summary of the findings along with a synthesis in light of the research questions posed within this thesis (C.I). It continues with a presentation of implications for research and practice (C.II), limitations and further research opportunities

(C.III), as well as concluding remarks (C.IV). Figure A-1 depicts the basic structure of this thesis.

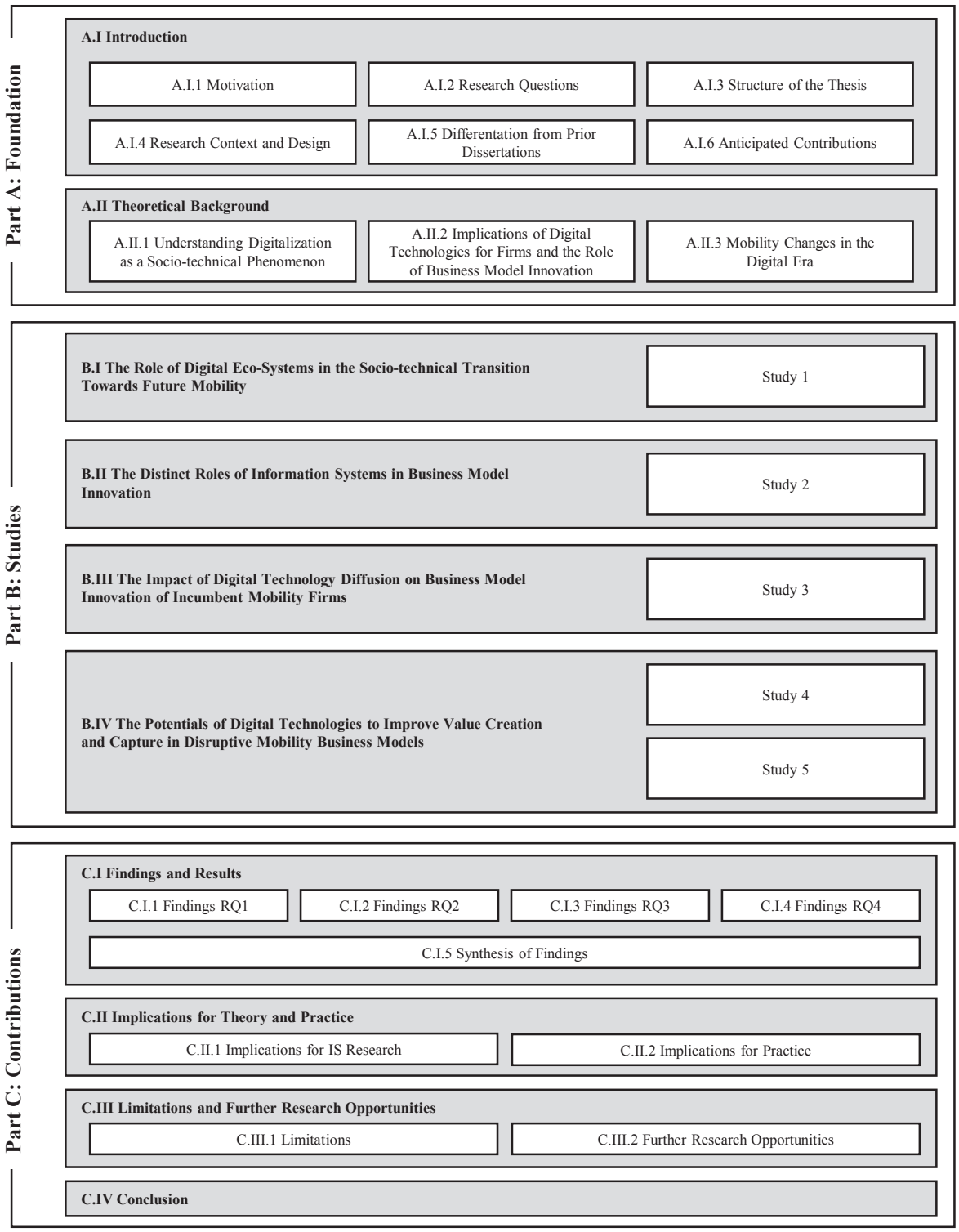


*Figure A-1. Structure of this thesis*

## I.4 Research Context and Design

IS research aspires to provide insights on how "information technology (IT)—various technical artifacts for capturing, processing, transmitting, and representing information—can be effectively infused into the human enterprise…[meaning] any social arrangement that can be served or affected by or can serve the uses of IT, ranging from use by individuals, teams, organizational units, and organizations to use by communities, markets, industries, and societies" (Grover and Lyytinen, 2015, p. 272). The relatively young and interdisciplinary research field of IS involves contributions from several backgrounds, such as management, philosophy, sociology, psychology, physics, mathematics, and computer science (Gregor, 2006). To account for the diversity of research domains as well as their underlying beliefs and philosophical positions, it is important to disclose the general assumptions that guide a research project, that is, its research paradigm, epistemology, and applied methods (Hevner et al., 2004; Orlikowski and Baroudi, 1991; Wilde and Hess, 2007).

Concerning the research paradigm, IS scholars differentiate between two broad approaches: design science and behavioral science (Hevner et al., 2004). Research following the design-science research paradigm seeks to design, create, and evaluate technology-oriented artifacts to solve organizational problems (Hevner et al., 2004). This positioning was largely influenced by the seminal work of Simon (1996) and aims to provide better solutions for real-world phenomena (Kuechler and Vaishnavi, 2008). In contrast, the behavioral-science paradigm originates from natural science research and aims to develop and justify theories (i.e., principles and laws) to explain, understand, or predict phenomena concerned with interactions amongst people, information technology, and organizations (Hevner et al., 2004). This thesis does involve certain design-oriented aspects, as it contributes IS artifacts in the form of models or situated software implementations (Gregor and Hevner, 2013). For example, Study 2 contributes a taxonomy that can be used by practitioners as a generic template for analyzing how IS can be applied to keep their business models relevant through innovation, whereas Study 5 involves the implementation of an IS-enabled bonus scheme to motivate carsharing customers to mitigate reckless and wasteful driving. However, these elements are primarily considered as by-products of the thesis. The main focus of this work lies on gaining a comprehensive understanding of how pervasive digital technologies lead to transformational change in the socio-technical mobility landscape. Hence, this thesis mainly follows the behavioral-science research paradigm.

With regard to the underlying epistemology, i.e., the assessment and justification of knowledge claims (Wynn and Williams, 2012), one can distinguish three general positions: positivist, interpretivist, and critical research (Gregor, 2006). Positivist studies assume the existence of a single and objective reality (Hudson and Ozanne, 1988) and are primarily used to test, confirm, or falsify theory in order to increase the understanding and predictability of real-world phenomena (Wynn and Williams, 2012). To do so, researchers following this position "work in a deductive manner to discover unilateral, causal relationships, that are the basis of generalized knowledge" (Orlikowski and Baroudi, 1991, p. 10). In contrast, interpretive research is based on the belief that there are many perceived

realities that cannot be understood a priori, because they are socially constructed (Hudson and Ozanne, 1988). To account for the changing and context-specific nature of perceived realities, interpretivists usually employ a continually evolving research design that helps them understand the subjective meanings behind actions (Hudson and Ozanne, 1988; Wynn and Williams, 2012). Finally, critical realism (also known as critical research) combines elements of the two previously mentioned positions to provide alternative approaches for knowledge development (Wynn and Williams, 2012). Similarly to positivist research, critical realism assumes an independent reality composed of fixed entities. However, this position further acknowledges "that the world is not easily reducible to our perceptions and experiences. In other words, the nature of reality is not easily and unproblematically apprehended, characterized, or measured, which means that humans experience only a portion of it" (Wynn and Williams, 2012, p. 790).

This thesis adopts a positivistic stance, meaning that it acknowledges the existence of an independent reality. This reality, however, is fragmentable, allowing for accurate observations of the phenomenon (Hudson and Ozanne, 1988). Therefore, each of the research papers constituting this cumulative dissertation focuses on a separate aspect of this reality in order to gain profound insights into the research subject. To do so, a mixed-methods approach is applied, combining qualitative and quantitative research to provide distinct perspectives on the same phenomenon and thus enriching its understanding (Venkatesh et al., 2013). The first two studies are primarily qualitative and exploratory in nature, delivering a solid theoretical foundation upon which Studies 3, 4, and 5 can provide quantitative and confirmatory analyses (Venkatesh et al., 2013). By covering both providers' and consumers' perspectives, this thesis seeks to deliver a comprehensive understanding of the causal relationships between the ongoing diffusion of digital technologies and business model changes in the mobility sector. Table A-2 presents an overview of the research design for each study.

*Table A-2. Overview of research design*

| No | RQ | Paradigm | Epistemology | Methodology | Data collection | Data analysis |
|---|---|---|---|---|---|---|
| 1 | 1 | Behavioral science | Positivistic | Framework development | App store analysis (*N* = 186) | Content analysis |
| 2 | 2 | Behavioral science | Positivistic | Taxonomy development (Nickerson et al., 2013) | Structured literature review | Taxonomy development |
| 3 | 3 | Behavioral science | Positivistic | Longitudinal panel data analysis (Ahuja and Katila, 2001) | Database retrieval | Multivariate regression analysis |
| 4 | 4 | Behavioral science | Positivistic | Conjoint analysis (Hill, 2013) | Online survey (*N* = 221) | Logit choice analysis |
| 5 | 4 | Behavioral science | Positivistic | Quasi-experiment (Campbell and Stanley, 1963) | Quasi-experimental time-series design (*N* = 2,983) | Multivariate regression analysis |