I Introduction

The first section (I.1) introduces the motivation for this paper and discusses the relevance of the examined research domains, followed by an analysis of prevailing research gaps and formulation of prevailing research questions (I.2). The third section (I.3) provides an overview of the thesis structure, while section I.4 explains the research design and its positioning within the philosophy of science. Lastly, the introduction concludes with an overview of anticipated contributions of this cumulative thesis (I.5).

I.1 Motivation

"Information System" (IS) research seeks to shed light on the impact and effects of applied and emerging information technologies and systems. Thus, IS research provides both theoretical and practical contributions by facilitating our general ability to understand, interpret, adapt, analyze, and manage such technologies (Banker and Kauffman 2004). IS research is primarily approached from two distinct schools of thought: design-oriented and behavior-oriented research (Arnott and Pervan 2012; Hevner et al. 2004; Iivari 2015). Research following the behavior-oriented research paradigm facilitates IS knowledge through the development and analysis of cause-effect theories whose primary function is to describe, explain and/or predict behavior (Gregor 2006). In contrast, the design-oriented paradigm values practical utility over truth (Iivari 2015) with the goal of facilitating the effective design of IS artifacts (Gregor 2006), an important task in today's increasingly digitalized economy (Lusch and Nambisan 2015; Piccinini et al. 2015; Simon 1996; Vargo and Lusch 2008).

Despite offering a proactive problem-solving approach to tackle significant challenges facing the IS domain, design-oriented research remains less common among IS scholars (vom Brocke and Seidel 2012; Simon 1996). Design-oriented research is often associated with the "Design Science Research" (DSR) paradigm (Hevner et al. 2004; Simon 1996), which focuses on gathering insights from the environment regarding a prevailing problem or challenge and combining these with information and methods from the knowledge base to develop artificial solutions (Baskerville 2008; Gregor 2006; Hevner et al. 2004; Winter 2008). In turn, the collectively synthesized knowledge systematically provides structured design theory guidance while inherently facilitating a deeper understanding of design principals, design patterns and solution architectures (Gregor 2006; Gregor and Jones 2007).

DSR offers two interconnected fields of research: *how to design solutions* and *how to research solution design* (Winter 2008). Thus, DSR is not only about solving problems and developing artifacts, but also about designing more effective and efficient problem-solving and research approaches (Baskerville 2008; Winter 2008). In this regard, applied DSR also provides new knowledge on its successful application. Reflecting on this is especially important, as DSR has recently been criticized for its state of 'conceptual confusion' (Iivari 2015, pp. 107), speculatively caused by the multitude of problems and sometimes ill-fitting solution development approaches. Consequentially, a stronger focus on IS research design is needed within the DSR research domain in order to provide conceptual and methodological clarity regarding the application of DSR (Iivari 2015; Winter 2008).

Regarding the application of DSR principles for development of theoretical design insights, the promising domain of Green IS is expected to yield valuable and impactful contributions (vom Brocke and Seidel 2012). Due to its focus on the important topic of IS-induced environmental sustainability, the "Green IS" domain holds a special position within the IS research community (Elliot 2011; Watson et al. 2010). Research within this domain has the capacity to make contributions to crucial challenges such as increasing resource efficiency, reducing greenhouse gas emissions and waste, and mitigating global climate change (vom Brocke, Watson, et al. 2013; Gholami et al. 2016; Seidel et al. 2013). Green IS scholars strive to enable sustainable solutions and behavioral change by individuals, organizations, and our society at large through IS research (vom Brocke, Watson, et al. 2013; Elliot 2011; Melville 2010). In addition to analyzing the behavioral influence of existing IS (van Aken 2013; Arnott and Pervan 2012), Green IS research also seeks to develop new and innovative artifacts (vom Brocke and Seidel 2012; Malhotra et al. 2013). For example, recent Green IS research has resulted in the development of several important practical artifacts which have contributed significantly to economic sustainability, including IS for emission monitoring, remote work (vom Brocke and Seidel 2012) and sustainable transportation services (Brendel and Mandrella 2016). Thus, the intersection of DSR and Green IS research provides a valuable domain for future research regarding not only the development of environmentally sustainable artificial solutions, but also in the context of deepening our methodological understanding of DSR.

Increasing urbanization poses one such environmental challenge in the transportation industry, and proves to be particularly urgent due to the continued escalation of resulting problems such as emissions and traffic (Metz 2012; Willing et al. 2017). It is estimated that by 2050, the proportion of inhabitants residing in urban areas will increase from the current 54% to 66% of the total global population (UN-DESA 2014). As a result, private car-bound mobility is becoming less feasible with the increasing concentration of residents per square meter. At this rate, addressing increasing urbanization with roads and parking space would be impractical, if not impossible to meet with the dominant car-bound mobility setting of many cities, as this solution would likely lead to increased traffic congestion and road safety hazards, and higher rates of noise and emissions pollution (Nijland et al. 2015; Nykvist and Whitmarsh 2008; Pavone et al. 2012). In response, mobility providers have to develop environmental friendly, flexible and dynamic alternatives to private car ownership to complement the current public transportation infrastructure (Nykvist and Whitmarsh 2008) – thus facilitating smart and sustainable mobility (Ambrosino et al. 2015; Hietanen 2014; KPMG 2014; Salon et al. 2014). In this context, “Shared Vehicle Services” (SVS) are proposed as a valuable means for developing a sustainable mobility infrastructure, addressing the developmental challenges of the current and future mobility (Cepolina et al. 2015; Laporte et al. 2015; Remane et al. 2016; Willing et al. 2017).

In SVS, multiple privately owned vehicles are replaced with a shared vehicle (Firnkorn and Müller 2011; Nijland et al. 2015; Wagner and Shaheen 1998; Wagner et al. 2014). One prime example of SVS is carsharing (Remane et al. 2016; C Willing et al. 2016), which allows its customers to rent a vehicle from a fleet distributed in an operation area (Boyaci et al. 2014; Jorge and Correia 2013). Carsharing relies heavily on digital infrastructure for day-to-day operations, namely for vehicle reservation, access and monitoring platforms (Remane et al. 2016; Shaheen and Cohen 2013). Due to its inherently digitalized business model, carsharing provides an ideal platform for showcasing both the environmental and economic advantages of IS-enabled smart mobility through SVS (Ambrosino et al. 2015; Neirotti et al. 2014). Studies have revealed a reduction in customer use of car-bound mobility options of nearly 30% favoring an increase in preference for alternate modes of transportation such as bike, bus and train (Martin and Shaheen 2011; Nijland et al. 2015). Beyond providing environmental benefits such as reduced carbon dioxide emissions, the decreased demand for car-bound mobility driven by increased preference for carsharing combined with public transportation also alleviates other symptoms of rapid urbanization including reduction in parking demand and decreased noise pollution (Martin and Shaheen 2011; Nijland et al. 2015). Furthermore, carsharing is flexible and offers short-term transportation, which can supplement classical public means of transportation to form a comprehensive mobility chain (Hildebrandt et al. 2015; Nawangpalupi and Demirbilek 2008; Willing et al. 2017). Lastly, carsharing can further reduce emissions by including “Battery Electric Vehicles” (BEVs) within the vehicle fleet (Wappelhorst et al. 2014; C Willing et al. 2016). Considering the array of benefits associated with carsharing, it is not surprising to find this increasingly popular mobility alternative consistently described throughout literature as a promising transportation service for urban areas (Martin and Shaheen 2011; Nijland et al. 2015).

Another promising application of SVS is the concept of “Shared Autonomous Vehicles Services” (SAVS), which is also referred to as self-driving-taxi services. “Autonomous Driving Vehicles” (ADV) can be rented on-demand and are self-driven to the customer’s location for pickup. After usage, the customer can release the ADV at his/her destination for the next customer to use (Fagnant and Kockelman 2014; Kornhauser et al. 2013). Through this system of flexible pickups and drop-offs, SAVS offer a dynamic and convenient mobility service. Furthermore, it is estimated that a single shared ADV can replace up to eleven privately owned vehicles (Fagnant and Kockelman 2014). As SAVS systems are expected to be electric, the usage of BEVs will further contribute to the sustainability of this new mobility solution (Chong et al. 2013; Fagnant et al. 2015; Fagnant and Kockelman 2014). Overall, “Shared Autonomous Electric Vehicle Services” (SAEVS) provide an all-encompassing addition to the environmental friendly mobility menu of the future. Therefore, it is important to proactively optimize SAEVS operation strategies to ensure a market-ready launch for rapid mainstream adoption.

However, while such potential mobility options offer exciting and innovative solutions for modern transportation challenges, both presented SVS instantiations suffer the problem of frequent location-based supply-demand imbalances (Bischoff and Maciejewski 2016; Fagnant and Kockelman 2015; Di Febbraro et al. 2012; Wagner et al. 2015). In case of carsharing, vehicles gathering in low demand locations increase the possibility of consequential system rejections of customer rental requests in high demand locations due to the misdistribution of vehicles (Di Febbraro et al. 2012; Wagner et al. 2015). Furthermore, in case of SAEVS, vehicle supply-demand imbalances can increase customer waiting time in high-demand areas (Fagnant and Kockelman 2014). In both cases, the SVS cannot fully achieve its potential as a flexible, environmentally friendly and reliable substitute for privately owned vehicles. Thus, both services require IS-enabled solutions for “Vehicle Supply and Demand Management” (VSDM) in the form of “Decision Support Systems” (DSS).

The many challenges managers face in providing efficient VSDM and addressing the related vehicle relocation problem all stem from the same core question: *how can SVS companies supply the vehicles customers demand?* However, varying business models, infrastructures and vehicle fleet compositions add different facets to the problem and must be individually addressed. Thus, to facilitate an understanding of effective solution design for answering this overarching question, it is necessary to first investigate sub-problems and design solutions for them, followed by abstraction of requirements, design elements and solution approaches that best fit the greater context (Gregory and Muntermann 2014; J. S. Lee et al. 2011) of VSDM in SVS. This thesis aims to contribute to the aforementioned research domains through rigorous description of relocation sub-problems, development of corresponding artificial solutions, and formulation of design theories based on developed artifacts and their analogous design processes. The developed design theories will not only facilitate knowledge and design relevant for the individual problem, but also for the entire overarching VSDM problem class (Baskerville 2008; Winter 2008), thereby contributing significantly to the domain of SVS research. Furthermore, as previously described, it is also important to investigate the knowledge gathered regarding the application of DSR. Hence, the application of DSR for different VSDM sub-problems will be accompanied by a design-process-focused reflection and gathering of implications and guidelines for DSR application, aiming to foster a deeper understanding of DSR in general (Iivari 2015).

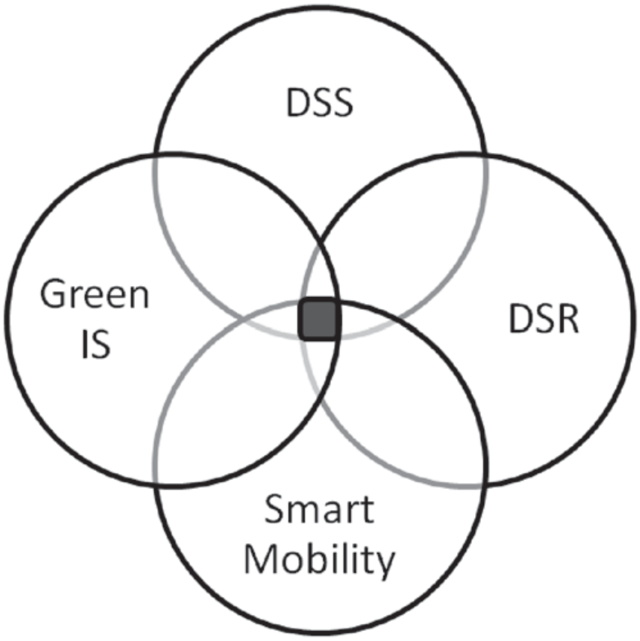

Figure 1: Thematically Interconnected Research Domains in this Thesis

In summary, this thesis aims to address important and relevant research gaps at the intersection of Green IS, DSS, Smart Mobility and DSR (see Figure 1).

I.2 Research Gaps and Research Questions

This thesis seeks to address the aforementioned challenges of developing IS-based solutions with the goals of facilitating more efficient and sustainable VSDM in SVS and also gathering insights into methodological and systematic applications of DSR. Thus, the research objective of this thesis is threefold, encompassing: problem description, artifact design, and reflection on DSR application.

The first step of every DSR process is to obtain a deeper understanding of the research problem and gain relevant requirements for future design of the potential