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Why Specialized Service Ecosystems Emerge—the Case of Smart Parking in Germany

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Abstract
Traffic caused by drivers searching for a free parking space has numerous negative effects, such as increased emissions and noise pollution. Innovative solutions can reduce these negative effects by providing car drivers with better information via a smart parking app. However, smart parking apps currently do not offer overarching solutions which support the entire parking process. Utilizing a service-dominant logic perspective, we examine why such overarching solutions do not emerge, whereas specialized ecosystems flourish. We follow a multiple case study approach and conduct qualitative interviews with three app providers and fourteen associated parking operators in Germany. Our results show how conflicting institutional arrangements at the micro, meso, and macro context levels lead to specialization. Our study deepens the understanding of how conflicting institutional arrangements affect the emergence of service ecosystems, drawing practical recommendations to overcome specialized smart parking apps in favor of overarching solutions.

Keywords Smart parking · Service-dominant logic · Multiple case study · Institutional arrangements · Service ecosystems

1 Introduction

The dominant use of private cars for mobility leads to numerous problems. Especially in cities, drivers waste valuable time waiting in traffic and searching for a free parking space. For example, INRIX (2017) shows that it costs car drivers around 41 h per year to find free parking spaces in cities in Germany. This additional traffic caused by drivers searching for a free parking space is called "parking search traffic." In addition to the loss of valuable time, parking search traffic has additional negative consequences, such as greenhouse gas emissions, noise pollution, and a financial burden for the driver due to the waste of fuel (e.g., Perković et al., 2020; Shin & Jun, 2014; Shoup, 2006). Although there are multiple approaches to reducing private car use, such as the provision of apps that make other mobility services such as public transport or bike-sharing more convenient (e.g., Schulz et al., 2023, 2021), it is not likely that private cars will lose its position as the most important means of transport in developed countries.

Information technology (IT) offers opportunities to make private car use more efficient, for example, by providing drivers with information about accessible parking spaces. According to Watson et al., (2011, p. 59), a prerequisite for a change toward more sustainable behavior is providing the "right information at the right time." In addition to whether a parking space is free, information such as the fastest route to parking spaces, the maximum parking time, and the parking fee is essential. Smartphone apps (hereafter apps) can provide this information through smart parking assistant services that rely on sensors, big data, open data, new ways of connectivity and exchange of information (e.g., Internet of Things, RFID, or NFC) as well as abilities to infer and reason" (Gretzel et al., 2015, p. 179). Through these smart parking assistants, cities can reduce parking search traffic and contribute to greater environmental, economic, and social sustainability.

Overall, there is a large body of scientific literature on smart parking. Various studies focus on a technical perspective of smart parking, such as the development and comparison of different sensors, cameras, and radar sensors, to monitor whether a parking space is free (e.g., Al-Turjman

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& Malekloo, 2019; Barriga et al., 2019; Idris et al., 2009; Perković et al., 2020), or the programming of a parking guidance algorithm (Shin & Jun, 2014). Other studies examine the potential economic and environmental impact of smart parking (e.g., Rodier & Shaheen, 2010). However, although research in various contexts has shown that the interplay of technical and social aspects is crucial for the implementation of information systems (IS) applications and the emergence of successful ecosystems (Sarker et al., 2019), research on smart parking that takes a non-technical but socio-technical perspective is still rare (Chovani & Jokonya, 2019). For instance, in the case of smart parking, socio-technical factors include the payment habits of potential users or the willingness to share personal data with smart parking providers. Although the technical prerequisites for smart parking might be given, these factors can hinder the emergence of overarching smart parking ecosystems, as users do not exploit the technical possibilities. Therefore, our research bridges important insights of interdisciplinary fields, such as IS, behavioral sciences, and economics to open up new perspectives on the topic of smart parking.

An example for the socio-technical perspective are service ecosystem that represent an actor-to-actor network and is defined as "a relatively self-contained, self-adjusting system of mostly loosely coupled social and economic (resource-integrating) actors connected by shared institutional logics" (Lusch & Nambisan, 2015, p. 161). In a smart parking ecosystem, actors such as the app provider, end users, and cities, including public transportation companies, constitute a service ecosystem. Previous studies in this context examine why actors do not join a service ecosystem (Schulz et al., 2023) or the service platform (i.e., the app) used by the actors for service exchange has a limited functional range (Schulz et al., 2020). However, these studies do not provide insights into how different specialized service ecosystems emerge in specific areas, such as in the case of smart parking, to overcome specialization and provide more attractive, overarching solutions for (potential) users instead.

Based on the institutional logics or institutional arrangements (Vargo & Lusch, 2017), actors in the ecosystem co-create value. Institutional arrangements consist of interrelated institutions representing rules, norms, and beliefs (Vargo & Lusch, 2017). For smart parking ecosystems, institutional arrangements include, for example, rules about processing parking data or beliefs regarding the best business model of app providers for end users. Therefore, institutional arrangements are highly significant for understanding the emergence and design of service ecosystems. If, for example, the rules about processing parking data differ for an app provider and a parking provider, these parties will most likely not initiate cooperation (i.e., form an ecosystem). Scientific knowledge about institutional arrangements in general (Vargo & Lusch, 2017) and smart parking ecosystems, in particular, is still very limited. To fill this research gap, we analyze which institutional arrangements of the actors in a smart parking ecosystem lead to specialized rather than overarching ecosystems, posing the following research question: *What factors lead to specialized rather than overarching smart parking ecosystems?*

We choose Germany as our context of the analysis because the impact and significance of institutional arrangements are particularly evident in smart parking ecosystems there. In Germany, app providers are still struggling to gain a foothold in cities due to the complexity of smart parking ecosystems. Consequently, only a few cities are currently cooperating with smart parking app providers. In addition, conflicting institutional arrangements in Germany lead to highly fragmented smart parking ecosystems that do not support the entire parking process, which includes the search for a free parking space, navigation to it, and digital payment (Hassoune et al., 2016; Idris et al., 2009). This focus of the apps on a specific phase of the parking process leads to specialized instead of overarching smart parking ecosystems, which makes them unattractive to potential users, as it requires the use of multiple apps for a single parking process.

In our study, we take the service-dominant (S-D) logic perspective (Vargo & Lusch, 2004) on embedded institutional arrangements (Vargo & Lusch, 2017), follow a multiple case study approach and conduct qualitative interviews with three app providers and fourteen associated parking operators from Germany to reveal how specialized smart parking ecosystems emerge. The level of analysis is the smart parking ecosystem comprised of the smart parking app provider, the cooperating cities or companies, and the end users, with different underlying institutional arrangements. Based on a cross-case analysis, we reveal the impact of different institutional arrangements on the emergence of specialized ecosystems.

With our research, we combine thorough theoretical analysis to tackle the practical problem of smart parking burdens in Germany, using insights from the scientific literature and interview data from smart parking industry specialists. Moreover, we combine these insights with a socio-technical lens to cover behavioral and technological perspectives in our research to explore multiple frontiers of the smart parking problem. We contribute to theory by providing insights into how conflicting institutional arrangements affect the emergence of overarching smart parking ecosystems (Vargo & Lusch, 2017). Our results show that especially political arrangements, end-user preferences, data provision and management, digital billing and payment options, and cooperation among app providers and cities/ companies lead to specialized ecosystems. Moreover, we shed light on the role of the concept of 'smartness' for our research and how it supplements former research on smart technologies and smart cities (e.g., Alter, 2020; Kar et al., 2019; Sharma et al., 2023). Our practical contributions include recommendations on how to overcome specialized ecosystem structures to create overarching smart parking solutions.

2 Theoretical Background

2.1 Service-Dominant Logic Perspective

The service-dominant (S-D) logic perspective was introduced in marketing by Vargo and Lusch (2004) and has been applied by scholars from various academic fields (Vargo & Lusch, 2017), including IS (Brust et al., 2017; Haki et al., 2019; Lusch & Nambisan, 2015). The S-D logic perspective has been used in IS to analyze different research topics, such as customer relationship management, business models (Turetken et al., 2019), and service ecosystems (Breidbach & Maglio, 2016). Moreover, the S-D logic perspective has been applied to the area of smart mobility, for example, to analyze how digital innovation can be induced in the mobility market to optimize end-user experiences with IS (Turetken et al., 2019). The essence of the S-D logic perspective is captured by its three main concepts: (1) service ecosystem, (2) service platform, and (3) value co-creation (Lusch & Nambisan, 2015).

A **service ecosystem** represents an actor-to-actor network and is defined as "a relatively self-contained, self-adjusting system of mostly loosely coupled social and economic (resource-integrating) actors connected by shared institutional logics and mutual value creation through service exchange" (Lusch & Nambisan, 2015, p. 161). Based on this definition, the different smart parking actors, such as the app provider and car-sharing and public transport companies, who use an app to provide users with information and access to multiple mobility services, constitute a service ecosystem (e.g., Schulz et al., 2023, 2021). One or more of these actors may be embedded in several service ecosystems at the same time (Akaka et al., 2013).

Lusch and Nambisan (2015, p. 162) define a **service platform** as "a modular structure that consists of tangible [e.g., IT hardware] and intangible components (resources) and facilitates the interaction of actors and resources (or resource bundles)." Actors use service platforms to provide and access services more effectively (Lusch & Nambisan, 2015; Storbacka, 2019). Based on this explanation, smart parking apps and parking sensors can be regarded as service platforms.

Value co-creation is based on service exchange among actors (Vargo & Lusch, 2017). A significant difference to the goods-dominant (G-D) logic perspective is that the customer is engaged in the service exchange (i.e., value co-creation) (Vargo et al., 2008). For example, rather than a car manufacturer attributing a specific value to a vehicle through its production, customers determine and create the value of the car by driving it. Value co-creation can also be identified through a positive change in the well-being of an actor (e.g., Chen et al., 2021; Schulz et al., 2021). In the situation above, for example, the value of the car is created when customers' well-being is improved by driving it. In the IS research field, the concept of value co-creation has been adopted for different contexts. For instance, value co-creation mechanisms have been analyzed for business-to-business IT platforms (Schreieck et al., 2017) or in nascent digital platform ecosystems (Hodapp et al., 2019). However, our knowledge about value co-creation is still limited, especially in technology-enabled contexts, as analyzed in IS research (Breidbach & Maglio, 2016; Brust et al., 2017). Technological progress and breakthroughs (e.g., a camera-based, deep learning approach to detecting free parking spaces) and changes in industry logic continuously offer new opportunities for value co-creation worthy of exploration (Payne et al., 2008).

In addition to these three main concepts of the S-D logic, we also consider institutional arrangements and different context levels in our study to analyze the emergence of specialized smart parking ecosystems. **Institutional arrangements** coordinate the actors and their service-for-service exchange within a service ecosystem. Institutional arrangements consist of interrelated institutions, including rules, norms, and beliefs (Vargo & Lusch, 2017), and conflicting institutional arrangements constrain the service exchange among actors of a service ecosystem (Schulz et al., 2020a). For example, German public transport companies often do not provide real-time timetable data and electronic tickets to app providers due to tendering and related price competition. Building on Koskela-Huotari et al. (2016, p. 2964) assertion that "breaking, making, and maintaining" institutional' arrangements can facilitate service exchange among actors, we consider institutional arrangements highly significant for understanding the emergence of service ecosystems.

To analyze institutional arrangements in more detail, different levels of **context** should be included. According to Chandler and Vargo (2011, p. 40), "a particular context [can be defined] as a set of unique actors with unique reciprocal links among them." The authors distinguish three levels of context: (1) micro, (2) meso, and (3) macro (Chandler & Vargo, 2011). In the case of the micro-context level, a dyad is the unit of analysis, and the direct service exchange between the two actors, such as an app provider and a cooperating parking company, is examined. At the meso-context level, the focus is on a triad, for example, on an app-provider—parking company and a parking company—end-user relationship where indirect service exchange takes place. In contrast, the macro-context level focuses on complex ecosystems, examining how actors, dyads, and triads engage in direct and indirect service exchange. Since focusing solely on the macro-context level is insufficient to understand the value co-creation in a service ecosystem (Akaka & Vargo, 2015), we consider institutional arrangements at all three context levels to approach the emergence of smart parking ecosystems.

Figure 1 illustrates all the above-mentioned concepts and relationships of S-D logic for a smart parking ecosystem using an exemplary use case. Specifically, the figure depicts the different context levels, the value co-creation processes between the actors, and the institutional arrangements as the foundation of the value co-creation activities for each actor. In the following, we will analyze the institutional arrangements for each actor to understand how they lead to specialized instead of overarching service ecosystems in the case of smart parking in Germany.

2.2 Smart Parking

The term smart parking can be anchored in the scientific literature in two ways. First, in the service and technology literature (e.g., Barile & Polese, 2010; Sharma et al., 2023; Wünderlich et al., 2015, p. 443), the addition of the term 'smart' highlights the emergence of a new service type "that is delivered to or, via an intelligent object, that is able to sense its own condition and its surroundings and thus allows for real-time data collection, continuous communication, and interactive feedback." The concept of smartness includes different entities, such as devices, socio-technical systems, and automated systems (Alter, 2020), enabling different smart features, such as monitoring and optimization of services (Porter & Heppelmann, 2014). According to Sharma et al., (2023, p. 1293) such smart technologies can be characterized by three capabilities, namely"ubiquitous data, connectivity among objects, individuals, and organizations, and aggregation of information", which leads to"exceptional engagement and intelligence, personalization, customization, contextual interaction, and automation".

Second, the term 'smart parking' can be attributed to the 'smart city' concept (Brauer et al., 2015). The smart city concept can be defined as a "[…] high-tech intensive and advanced city that connects people, information and city elements using new technologies […]" (Bakıcı et al., 2013, p. 139). Smart technologies in smart cities can then be applied to address cities' environmental, economic, and social challenges (Gupta et al., 2019), increasing the overall quality of life. The smart city concept enables different data-driven approaches, such as 'smart mobility', by deploying traffic data to optimize urban mobility (Kar et al., 2019). Moreover, smart mobility (e.g., availability of ICT infrastructure and innovative transport systems)

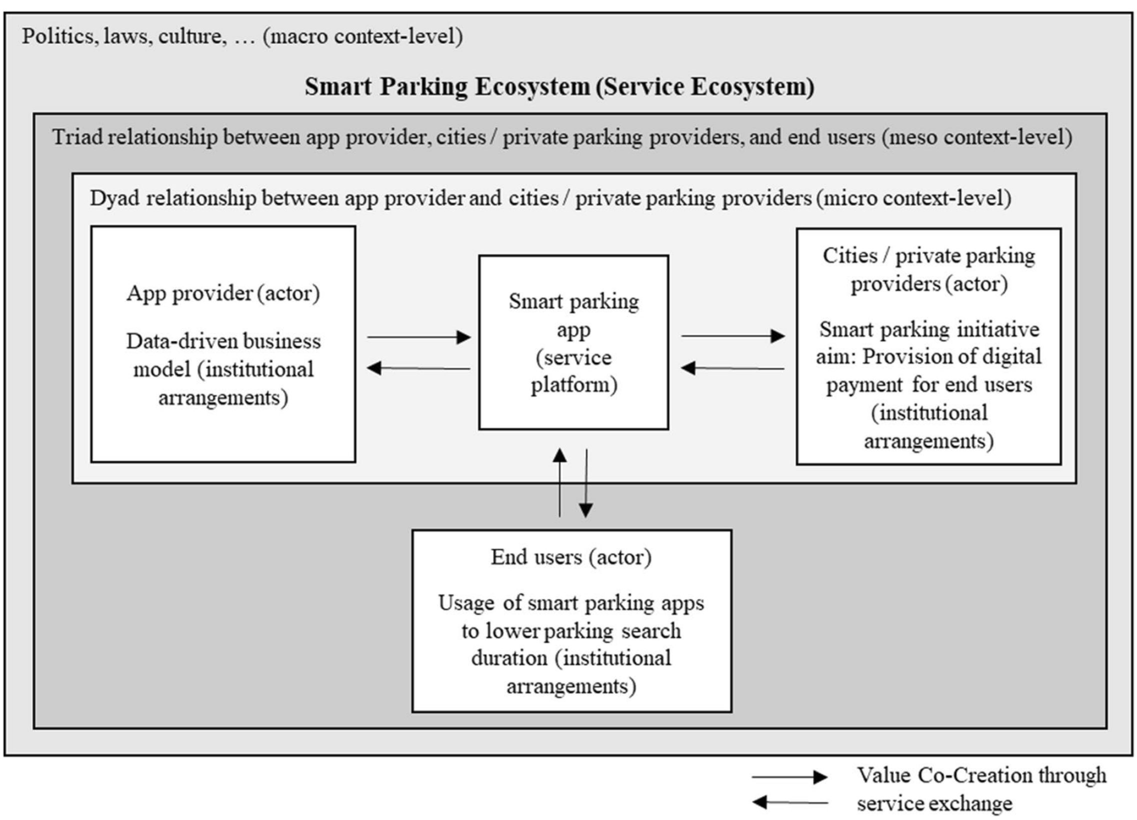

Fig. 1 Exemplary smart parking ecosystem based on the concepts of the S-D logic

involves the use of an app and sensors placed on the parking spaces to provide information about their occupancy (Giffinger & Haindlmaier, 2010).

Based on these concepts of smartness, smart parking is characterized in the literature as "[…] a way to help drivers find more efficiently satisfying parking spaces through information and communications technology […]." (Lin et al., 2017, p. 3229). Therefore, smart parking can be defined as a technology-driven approach aimed at optimizing the parking process through digital functionalities such as digital payment systems or real-time information on available parking spaces enabled by various sensors, all collectively contributing to behavioral shifts. Depending on the specific purpose of the smart parking system, different types of smart parking solutions can contain different systems and sets of functionalities (Diaz Ogás et al., 2020). However, a holistic approach, combining as many different functionalities as possible, is favorable to create overarching smart parking ecosystems.

The ability to reserve a parking space and pay digitally is an important function of smart parking solutions (Hassoune et al., 2016; Idris et al., 2009). Access to a reserved parking space can be automated, for example, by using a camera-based solution that scans the vehicle's license plate. According to Idris et al. (2009), smart payment systems are contactless (e.g., automated vehicle identification) or contact-based (e.g., credit card) solutions that do not require cash payment. In some cases, it is also possible to extend the parking time by smartphone, and dynamic prices are used as monetary incentives to use less popular parking spaces (Hassoune et al., 2016; Saharan et al., 2020). However, privacy and security concerns are two main hindrances to implementing smart payment systems (Al-Turjman & Malekloo, 2019; Idris et al., 2009). Furthermore, some studies analyze how the provision of smart parking solutions changes the behavior of car drivers regarding economic and environmental sustainability. For example, Rodier and Shaheen (2010) show how introducing a smart parking system can lower the drive-alone modal share, and Peng et al. (2017) and Mangiaracina et al. (2017) show that smart parking solutions contribute to the reduction of greenhouse gas emissions.

Most relevant studies published beyond the IS field predominantly focus on the technical solutions that support a car driver during the different phases of the parking process. Numerous studies provide an overview of previous work or on specific technical solutions available in practice, such as Barriga et al. (2019), Hassoune et al. (2016), and Idris et al. (2009), who classify smart parking systems according to their functionalities, such as digital payment systems. The provision of information about free parking spaces is one of the essential functions of smart parking solutions, for which a variety of sensors, such as cameras, magnetometers, or radar sensors, can be used (e.g., Al-Turjman & Malekloo, 2019; Barriga et al., 2019; Idris et al., 2009; Perković et al., 2020).

In summary, numerous smart parking studies take a technical perspective, and others focus on the behavioral changes caused by introducing a smart parking solution and related improvements in economic and environmental sustainability. Overall, there is a lack of studies examining socio-technical aspects, such as how the different actors (e.g., app providers, cities, and private parking operators) cooperate in practice. However, socio-technical aspects are crucial for IS implementations (Sarker et al., 2019), and a lack of understanding can hinder the emergence of overarching ecosystems as much as technical shortcomings. Our analysis of existing literature, therefore, shows that socio-technical factors leading to specialized ecosystems are so far not considered in the smart parking literature, although it is crucial to provide possible solutions to reach overarching smart parking ecosystems. To approach this question, we argue that the S-D logic perspective, with its embedded institutional arrangements on different context levels, is a suitable theoretical lens, as it enables an analysis of all services provided by the actors, their interrelationships, and the consequences for the emergence of specialized smart parking ecosystems.

3 Methodology

3.1 Case Study Research

In this study, we chose a multiple-case design to gain insights into the factors that lead to specialized instead of overarching service ecosystems for smart parking (Yin, 2018). To get an overview of smart parking solutions in Germany, we first analyzed the smart parking app market using archival data. To gain a deeper understanding of institutional arrangements leading to specialized ecosystems, we then conducted 17 interviews with app providers and city and private parking operators from three different smart parking ecosystems.

A case study research is defined as an analysis of "a phenomenon in its natural setting, employing multiple methods of data collection to gather information from one or a few entities (people, groups, or organizations)" (Benbasat et al., 1987, p. 370). In case study research, the boundaries of the phenomenon are not evident at the outset of the research, and no experimental control or manipulation is used. Our data collection methods include performing qualitative interviews and gathering data from archives (Eisenhardt, 1989). Case study research is considered appropriate when the research question is a 'why' or 'how' question, as in our study (Benbasat et al., 1987; Yin, 2018). In line with Benbasat et al. (1987), who argue that individuals, groups, and organizations are examples of cases, we define each service ecosystem as a case. The level of analysis is the app provider and the parking operators of a service ecosystem, as well as the institutional arrangements in which these actors are embedded.

Based on these criteria, we decided to investigate service ecosystems whose actors want to realize smart parking in German cities: (1) Germany has an extensive parking infrastructure that is suitable for the installation of sensors to detect free parking spaces. (2) There are laws and high public pressure that aim to make people's mobility behavior more sustainable. For example, due to the exceeding of legal limits for nitrogen oxides, it is forbidden to drive diesel cars in certain zones in some German cities like Berlin or Stuttgart (ADAC, 2019). (3) The results of previous studies (e.g., Schulz et al., 2023, 2021) show that the apps available on the market that support the switch from the private car to alternative mobility services still face numerous limitations in practice. For example, German public transport companies often do not generate real-time timetable data or operate a mobile ticketing system (Zimmermann et al., 2020). Smart parking apps, therefore, represent an important alternative to changing mobility behavior.

3.2 Overview of Smart Parking Apps

Table 4 in the appendix provides an overview of the app providers that focus on realizing smart parking in German cities and their apps, which we identified based on an online search. Our analysis shows that the number of cities covered by the app varies widely. While the ParkPilot Köln app can only be used in Cologne, some other apps (e.g., mobilet.de, PayByPhone Parken) can be used in more than 300 German cities. However, it should be noted that an app usually cannot be used for all parking spaces and parking garages operated by a city.

A function of some apps is that they help their users find an available parking space on the street, in parking garages, or in private and corporate parking spaces (e.g., Ampido, ParkHere Corporate). However, detecting free on-street parking spaces in real-time still seems to be a significant challenge due to the high number of parking spaces and, respectively, the high number of sensors that would be required. In some cities (e.g., Berlin, Hamburg), the ParkNow GmbH, therefore, uses a fleet of vehicles equipped with sensors to collect information about free parking spaces. However, most apps (e.g., PARCO) do not provide a comprehensive overview of available parking spaces in real-time, especially not on-street parking spaces.

In contrast, the provision of that information represents a core function of the ParkPilot Köln and CityPilot apps. Some of the apps also offer navigation to a (free) parking space (e.g., EasyPark, ParkPilot Köln). In some cases, the user is forwarded to Google or Apple Maps, Android Auto, or Apple CarPlay for navigation (e.g., CityPilot app, PARCO app). A handful of apps (e.g., ParkHere Corporate, PARK NOW) also offer the option of storing the license plate number to automatically open the barrier of closed parking spaces and garages and/or start the recording of the parking time, although only for selected parking spaces.

Digital payment of the parking fee is a core function of almost all apps. Several apps (e.g., Parkster, PARCO) offer the opportunity to purchase a parking ticket for a particular parking time and extend it if necessary. In some cities, however, a vignette or a handwritten note indicating the use of the app must be affixed to the vehicle to make it easier for inspectors to detect a possible parking violation. The Yellowbrick Germany app also offers users the opportunity to pay visitor parking fees. Invoicing of parking fees varies from immediately (e.g., PayByPhone Parken app) to weekly (Yellowbrick Germany app) or monthly (e.g., PARK NOW and PARCO app). App users usually have several payment options at their disposal, such as credit card, direct debit, and Paypal. This overview of the apps available for smart parking in German cities constitutes the basis for identifying suitable app providers for our data collection.

3.3 Data Collection

Based on the overview of the app providers and their apps available for smart parking in German cities, we identified appropriate cases (i.e., service ecosystems) for our data collection. The overall aim of our data collection was to find appropriate interview partners to gain a deeper understanding of the institutional arrangements that lead to specialized instead of overarching smart parking ecosystems. In our selection, we also paid attention that the service ecosystems differed in terms of the number of cities included in the app, the number of app downloads (i.e., the number of users), and the core functions of the apps, especially whether the app focuses on displaying free parking spaces or on the payment of the parking fee.

We requested interviews with the eight most appropriate app providers in terms of size and app functionalities. Our interview request was sent via email to the managing directors or, in one case, to the person responsible for business development. Three people responded positively and agreed to an interview. Further, we identified parking operators embedded in the respective service ecosystem through an online search (e.g., the website of the app providers). Our search revealed that some of the parking operators are members of the service ecosystem of more than one app provider. Based on a random choice, we selected 33 cities and private parking operators and conducted 14 interviews. On average, the 17 interviews lasted 26 min each. All interviews were conducted by phone or via computer software, such as Microsoft Teams and Zoom, from May to July 2021. All interviews were recorded and later transcribed.

The interviews followed a semi-structured guideline. Semi-structured interviews offer a high degree of flexibility, which makes it possible to address issues that come to light during the interview (Flick, 2009; Myers & Newman, 2007). The questions asked of the experts of the cities and private parking operators were slightly different and included, among others, questions about the interviewee's person, the city/company, and the cooperation with one or more app providers. In addition, we gathered secondary data (e.g., the city's parking fee schedule and information about other payment options for parking fees) to supplement the interview data.

Table 1 provides an overview of the three cases and the actors analyzed. The app providers and the cities are abbreviated with AP and C. The private parking operators are an airport (AIR), a parking space service company (PSS), and a public transport organization (PTO). The cities (C1, C2, C6, and C7) marked with * are members of the service ecosystems of app providers 1 and 2. C8, which is marked with **, is embedded in the service ecosystems of app providers 1 and 3.

3.4 Data Analysis

We analyzed the data collected using the software NVivo 12. The coding was done by one of the authors with several years of experience in qualitative research and data coding. The authors discussed the emerging coding structure and the preliminary results of the study in regular meetings. Such a common interpretation of the data material improves the reliability of the results (Miles et al., 2014). If the authors interpreted the data differently, discussions were held until a common understanding was reached. If necessary, the data material in question was re-analyzed. In addition, the data analysis includes the secondary data that we gathered, which enables us to verify and supplement the experts' statements. Such data triangulation increases the quality of data analysis results (Flick, 2009; Miles et al., 2014).

Because the S-D logic literature provides only limited knowledge of how institutional arrangements influence the emergence of service ecosystems (e.g., Schulz et al., 2020; Vargo & Lusch, 2017), we adopted a three-stage iterative coding approach (Strauss & Corbin, 1998). (1) In open coding, we identify the institutions and their rules, norms, and beliefs that enable or constrain the service exchange among actors (Schulz et al., 2020; Vargo & Lusch, 2017) and thus

Table 1 Overview of cases and actors

Case	Actor	Role of interviewee	Number of inhabitants	Number of parking garages	Number of parking spaces
Case 1	AP1	Managing Director			
	C1*	Smart City Manager	≤ 300,000	≤ 20	n.a
	C2*	Head of surveying department	≤ 150,000	≤ 10	n.a
	C3	Head of economic development	≤ 100,000	≤ 10	n.a
	C4	Traffic Planner	≤ 25,000	n.a	n.a
	C5	Mobility Manager	≤ 25,000	n.a	≤ 2,000
	C6*	Business Unit Manager for Digitization	≤ 150,000	≤ 10	≤ 6,000
	C7*	Head of department for civil engineering	≤ 100,000	≤ 20	n.a
	C8**	Employee environmental office	≤ 100,000	n.a	≤ 4,000
Case 2	AP2	Managing Director			
	C1*	Smart City Manager	≤ 300,000	≤ 20	n.a
	C2*	Head of surveying department	≤ 150,000	≤ 10	n.a
	C6*	Business Unit Manager for Digitization	≤ 150,000	≤ 10	≤ 6,000
	C7*	Head of department for civil engineering	≤ 100,000	≤ 20	n.a
	C9	Head of traffic control	≤ 25,000	≤ 5	≤ 2,000
	C10	Head of public safety and order department	≤ 25,000	n.a	≤ 4,000
	C11	Team leader for citizen services, registry office and public order office	≤ 25,000	n.a	≤ 2,000
Case 3	AP3	Employee Business Development			
	C8**	Employee environmental office	≤ 100,000	n.a	≤ 4,000
	AIR	Manager E-commerce / parking		≤ 5	≥ 10,000
	PSS	Head of organization department		n.a	n.a
	PTO	Employee bus transportation		≤ 5	≤ 4,000

influence the emergence of the service ecosystems for smart parking. (2) Our axial coding is based on the assumption of the S-D logic perspective that multiple interrelated institutions constitute an institutional arrangement (Vargo & Lusch, 2017). In other words, based on the open codes, we formed sub-categories depicting institutional arrangements that are in place in the service ecosystems (Vargo & Lusch, 2017), such as the use and management of data, and explain on a more detailed level why specialized service ecosystems emerge. (3) in selective coding, we used the sub-categories to create categories that cover the contextual levels – micro (dyad), meso (triad), and macro-level (Chandler & Vargo, 2011) – to which each institutional arrangement is linked. We then compared the coding for the three cases to gain insights into how different institutional arrangements lead to the emergence of specialized service ecosystems.

4 Results

In the following, we first present institutional arrangements on different contextual levels (macro, meso, and micro) to explain the main reasons for the emergence of each specialized smart parking ecosystem separately. Afterward, we examine cross-case similarities and differences to form overarching insights into smart parking ecosystems in Germany.

4.1 Case 1

Our first case includes the ecosystem of AP1 and the cooperating cities C1-C8. AP1 is one of the biggest smart parking providers in Germany, and its app is available in many different cities, inside and outside of Germany. Their app provides functionalities to help users find available parking spaces on the street and in parking garages, and they offer digital payment functions. According to AP1, they aim for overarching solutions for end users. Moreover, they offer tailored cooperation models, depending on the requirements of their partners, such as different pricing models (e.g., for park-and-ride areas), and cooperation to promote public transportation is getting more popular. (AP1).

At the **macro level,** we find institutional arrangements regarding politics, environment, and end-user preferences in Germany inhibiting an overarching integration of the smart parking ecosystem.

In four cities (AP1, C1, C2, C4, C8) and in the interview with the app provider, the interviewees stated that political reasons inhibit a broader integration of smart parking systems. While for C1 the integration of private parking areas to enhance the parking search system is the most relevant factor, C4 stated, "The conversion [to a smart parking system] costs money. And there must be political will to spend the money."

Making city traffic more environmental-friendly is considered one of the reasons to implement a smart parking system in cities (AP1, C1, C4) because "Less parking search traffic improves not only air quality but also noise and safety as well" (C4). However, there are also concerns that "Making city center parking more attractive will ultimately hurt the transportation transition and the shift to public transit and bicycles" (C1), which can inhibit further expansion of smart parking initiatives.

According to seven (C1-C3, C5-C8) representatives of the cities in this ecosystem, one of the main reasons (i.e., institutional arrangements) for the emergence of specialized smart parking ecosystems is conflicting end-user preferences in Germany. Most of the city representatives report that only a minor proportion of citizens, ranging from 2%-30% (C2, C3, C5, C7, C8), use the smart parking offers, and only C1 stated that "at the beginning, [the diffusion rate] was very slow, in the meantime, it should have spread much stronger." There are two major drivers of the lack of acceptance: many people living in Germany prefer to pay by cash rather than digitally (AP1, C7), and especially elderly people living in Germany are not skilled in using a smartphone (C3 and C7), whereas "Younger generations, in particular, have a very high digital affinity" (C3). City representatives are conscious that "[…] we must not exclude older generations who may still find these topics a little difficult" (C3).

At the **meso level,** we find that institutional arrangements regarding the billing process and data use foster overarching integration of the smart parking ecosystem, while data analysis inhibits overarching integration.

Regarding digital billing, AP1 stated, "I think you can see this topic under the aspect of making it as easy as possible to [fun and] use [available parking spaces]. That's where we try to help." The easier billing process, again, is also an important aspect for the cooperating cities. As mentioned by C1, "The way we currently operate [smart parking], it is only a pure processing advantage" (C1, C2, C3, C4, C5, C6, C7). Moreover, many city representatives consider the current form of their cooperation a starting point to drive digitization forward, as stated by C3: "I think we are generally in a digitization process in C3, where we are trying to digitize all processes […], and therefore it is also necessary that you digitize such billing processes" (C3, C5, C7).

The additional service regarding the billing process is not only relevant for the cities but is also extended to end users: "So basically, we see [payment via smartphone] as an additional service" (AP1). The cities also value this additional service for their citizens, especially considering the higher flexibility, as parking can be paid for "on the go" and not in advance for an estimated duration (AP1, C1, C2, C3, C6): "You can—depending on the provider—simply start the parking process to the minute and end it to the minute" (C2). Moreover, AP1 has integrated functionality for the payment of e-charging stations in their app, so end users only have to use one app and get one invoice at the end of the month (AP1, C8).

Beyond the simplified billing process, dynamic prices could be used by smart parking providers and cities to regulate the occupancy rates in individual parking areas. However, AP1 does not offer functionalities for dynamic pricing, and none of the city representatives considers it as important for their current smart parking concept (C1, C2, C3, C5, C6). Therefore, the lack of dynamic pricing functionalities in the app of AP1 seems not to influence current cooperation with the cities. However, C2 and C3 stated that they have been thinking about dynamic pricing concepts for the future.

Regarding the use of data, AP1 outlines its business model focusing on reducing parking search traffic and navigating drivers to free parking spots. To enable this business model, they analyze traffic flows and provide reporting about the usage of smart parking in each city/ private parking area. However, AP1 stresses, "The important thing is that it's not a business model of ours. We do not want to do data business" and "We are really a provider of parking or other automotive-related services."

Interestingly, most of the interviewed representatives of cities that cooperate with AP1 consider the opportunity of parking data analysis as an important feature of a smart parking system for themselves and their city's citizens (C1, C2, C4, C5, C6, C8). This includes functionalities to evaluate how big the current parking utilization rate is (C2, C4, C8), identify free parking spots to reduce parking search traffic (C2, C4, C6), or analyze which parking spots are occupied to ensure proper use of e-vehicle or handicapped parking (C1). In contrast, concerns about data privacy compliance are also a relevant aspect (C2, C7). Moreover, C5 and C8 stated that their cities strive for more comprehensive solutions to create more effective smart parking solutions, for example, by integrating different systems into one solution: "A platform will be created here […], where the e-charging station data and the parking data will be combined. Otherwise, you would always have two dashboards. And based on this data, you can also create parking heat maps." For C4, the lack of these functionalities even leads to a cooperation request of AP3, as this app provider has a stronger focus on data analytics: "The advantage is, especially with [AP3], that you know before you leave where a parking space is free when you arrive at a destination."

At the **micro-level,** we find institutional arrangements for the cooperation motive, the implementation process, and the pricing model foster overarching integration of the smart parking ecosystem while checking parking tickets inhibits overarching integration.

Regarding the cooperation motives, the requirement to create overarching solutions for end users is highly relevant for many cities (C1, C2, C3, C5, C6, C7). As stated by C3, "The concept was also very interesting for us because surrounding municipalities cooperate with the same provider. And from the customer's point of view, we chose […] this provider." Addressing this requirement often leads to more than one cooperation with a smart parking app provider because "Ultimately, our focus was also on the greatest possible flexibility for citizens" (C6). Moreover, cooperating with various app providers enables platform solutions for cities, making many administrative processes easier to handle (C2, C6, C7). Besides these overarching motives, city representatives also stress the relevance of the digital payment feature (C1, C2, C3, C5, C7) and the reduction of park search traffic through data-supported information about current parking utilization rates (C3, C5, C6, C7) as provided by AP1.

The implementation process for the smart parking solution provided by AP1 is described as effortless, and most of the implementation is done by the provider (C1, C2, C3, C5, C6, C7). One reason for that might be that AP1 does not provide any sensors, but instead, they stated, "We use sensors. We are not a hardware provider at all" (AP1). However, some initial effort is attributed to the digitization of the parking areas (C1, C2, C5, C6) and the adaptation of parking ticket-checking devices and parking meters (C2, C3, C7) in the cities. These devices are necessary for checking the validity of on-street parking tickets, which is again considered a well-functioning and easy solution by many city representatives (C1, C2, C3, C5).

As AP1 only provides services and needs almost no additional infrastructure, the overall costs for the cities are relatively low, which promotes cooperation with this provider (C3, C5, C6): "No large infrastructure had to be set up; only the parking areas of AP1 had to be recorded and integrated into the system. Therefore, no major costs have been incurred on either side so far" (C5). In general, there is a basic amount for the cities and additional commission fees that can either be paid by cities as an additional service for their citizens or by the end users. Otherwise, prices for the end users remain the same as for non-smart parking.

4.2 Case 2

Our second case includes the ecosystem of AP2 and the cooperating cities C1, C2, C6, C7, C9, C10, and C11. The app of AP2 can be used in many different German cities and provides digital payment functionalities. Regarding their overall business model, AP2 stated that they cooperate with private companies and public institutions, and entities like cities and provide digital payment features for their clients. Cooperation with mobility providers to promote intermodal mobility forms, such as car-sharing companies or public transportation companies, is not within their scope. Moreover, they explicitly exclude the use of parking sensors or parking areas with gates, as they exclusively focus on their digital offering, i.e., their app services (AP2).

At the **macro level,** we find institutional arrangements regarding politics, technical prerequisites, and end-user preferences in Germany inhibiting an overarching integration of the smart parking ecosystem.

Political considerations are, comparable to ecosystem 1, relevant for the lack of broader integration of smart parking systems (C1, C2, C10, C11). Especially for C10 and C11, the main reason for the rather restrictive use of smart parking is the requirement of equality of smart and non-smart parking solutions for all citizens, as stated by C11: “We want to put everyone on an equal footing, so we do not use this nice advantage.”

While AP2 does not express political hurdles, the interviewee stated that one of the main hurdles at the macro-level to further expanding smart parking systems in Germany is the technical prerequisites: “In our case, [the biggest challenge] is definitely cell phone reception, we would have made a lot more sales and also been able to service a lot more parking spaces in Germany if cell phone reception had been better.”

We again find two major conflicting end-user preferences in Germany. First, according to C10 and C11, acceptance of smart parking solutions among end users (C2, C7, C9, C10, C11) only ranges between 10–15%, meaning that most potential end users still prefer traditional parking solutions. Second, we find that the low level of smartphone use, especially as a means of payment in Germany (AP2, C7, C9, C10, C11), is considered one of the main reasons for the low acceptance rates of smart parking. AP2, for example, stated, “I think one of the most important points is that smartphone adoption is still difficult. Payment methods are also problematic…” and C9 summarizes: “Because there are many people who do not use or do not want to use a smartphone, as is needed in the smart parking sector. So, in particular, the older population […]is not on the go with their smartphones, they don’t park with their smartphones, they don't pay with their credit cards or smartwatches, but they still have money in their wallets and want to pay with it.”

At the **meso level,** we find that institutional arrangements regarding the billing process foster overarching integration of the smart parking ecosystem, while the data use and analysis inhibit overarching integration.

Regarding the use of data, the interviewee from AP2 reports very limited use, i.e., no systematic analysis of data (e.g., to improve parking search traffic) and no provision of data to the cooperating cities. The even more restrictive data use by AP2 compared to AP1 is also evident in that parking sensors are not used to collect additional information, such as on parking area occupation rates. Moreover, they do not provide any steering functionalities through their app, such as dynamic prices or a display of free parking spots. Interestingly, they do realize that cities are often interested in such functionalities. However, they argue that “these are cool sales arguments, and it is well received by the cities. But for the end consumers or the utilization of parking spaces, it doesn't matter” (AP2).

Two of the city representatives interviewed identify the restrictive data management approach by AP2 as one of the main reasons for the cooperation with them because they are also interested in minimal use of data about citizens (C7, C11). Especially C2 and C7 express that data privacy compliance was very important in planning their smart parking concept. Moreover, C2 stated that they welcome the low costs for the implementation, as no sensors or other infrastructural investments are needed for cooperation with AP2. However, four interviewees (C1, C2, C6, C10) consider the additional use and analysis of data as beneficial at the city level but also for the citizens: "One approach, for example, is to reduce parking search traffic using digital technologies" (C6).

At the **micro-level,** we find that institutional arrangements for the implementation process and the pricing model foster overarching integration of the smart parking ecosystem, while cooperation motives and checking parking tickets inhibit overarching integration.

Overall, most city representatives interviewed agree that the implementation process with AP2 requires little effort (C1, C2, C6, C7, C9, C10) because no infrastructural or technical prerequisites, such as parking sensors, have to be fulfilled. However, C11 stated that the upfront digitization of the parking areas meant that “From this perspective, of course, we had a lot of work to do at the beginning” (C1, C2, C6). Regarding checking parking tickets, most city representatives stated that the effort required to offer smart parking tickets is comparable to traditional tickets (C1, C2, C6, C9, C11). Only C11 stated that “[…] this is the only extra work we have.”

Further, most city representatives report that the related overall costs, i.e., the costs for the implementation and ongoing operating costs calculated as a percentage of the overall acceptance rate, are relatively low (C6, C9, C10, C11). AP2 stated, “After all, we are the only app in Germany with no additional fees" and C9 confirmed, “… and that is how you want it to be. There are no additional costs for the parker, which is a decisive criterion [for cooperating with AP2].” Interestingly, some city representatives even consider the overall cost calculation beneficial because other expenses are considerably lower for smart parking compared to traditional solutions (C1, C2, C6, C7, C9, C11). For example, C9 stated, “I think overall we have a cost-saving. Because with parking ticket machines, you have the technical support of the machines, wear and tear of the machines, costs for paper, etc.” Similar to the reporting function for cities, end users also get a monthly report on their parking activities and overall expenses (AP2, C1, C2, C6). Dynamic prices, however, are not relevant for the provider AP2 nor for most cooperating cities (AP2, C1, C2, C6, C10, C11).

For the cities, the two main reasons for cooperating with AP2 are to improve parking services for their citizens (C1, C2, C6, C7, C9, C11) and to achieve administrative benefits for the city (C2, C7, C9). Improving the parking services for citizens includes the payment services offered by AP2 (C1, C2, C6, C7, C9, C11) as well as a more comprehensive understanding of smart parking services, leading to several cooperation agreements with different app providers for some of the cities, as mentioned above for the ecosystem of AP1 (C1, C2, C6, C7). However, the representative of C9 sees a disadvantage for end users of having several different providers: "The only downside to smart parking is that there are so many different providers with so many different approaches, and the whole market may be confusing for a customer who travels a lot [by car between cities]." We find that C1, C6, and C10 have not integrated gated parking areas into their (smart) city parking system but lease them to private providers. So although we cannot observe a causal relationship, the exclusion of gated parking areas by AP2 from their smart parking offerings might also hinder further integration for the cities.

4.3 Case 3

Our third case includes the ecosystem of AP3 and the cooperating cities and companies C8, AIR, PSS, and PTO. The business model of AP3 differs significantly from AP1 and AP2. AP3 asserts that the company's focus is not on digital payment or billing but on the provision of real-time data and infrastructure (e.g., sensors) to reduce parking search traffic. Moreover, AP3 explicitly stresses that they are striving to find overarching smart parking solutions by providing an API instead of an actual app for their customers so that their data can be integrated into other apps, such as other smart parking apps with payment functionalities or other mobility apps, such as public transportation apps (AP3).

At the **macro level,** we find institutional arrangements regarding politics and end-user preferences in Germany inhibiting the overarching integration of the smart parking ecosystem.

From the perspective of AP3 and PSS, political positions held by cities and municipalities are reasons for the slow integration of smart parking systems in many areas in Germany. AP3 stated, for example, "You can't always blame everything on politics, but we see it as very relevant that politics must set stronger guidelines and steer municipalities and cities and lead them into the digital world." Moreover, cities and municipalities are usually bound by procurement guidelines, and "This means that projects cannot be implemented as quickly, which may be faster in the private sector" (AP3). Also, the interviewee from PSS stated: "I believe that a change in thinking must first take place, especially among the municipalities and communities, which are still very, very reserved in this regard."

Besides politics, the awareness of end-users seems to hinder the emergence of overarching smart parking systems (AP3, C8, AIR, PSS). AP3 stresses, "You have to create awareness, you have to generate added value." AIR shares this point of view and concludes that "The main challenge is—with whatever digital processes you're looking at—is that it's understandable to the customer, that they understand as quickly as possible, what does it offer me and what do I have to do to get it.". So even though end-user preferences might hinder the further emergence of smart parking ecosystems, the providers and cooperating companies in Ecosystem 3 also feel responsible for changing this situation by offering suitable solutions valued by the end users (AP3, AIR).

At the **meso level,** we find that institutional arrangements regarding data use and analysis foster overarching integration of the smart parking ecosystem, while the lack of payment functionalities inhibit overarching integration.

As mentioned above, providing data is one of the core business functions or institutional arrangements by AP3. On a more detailed level, this includes the overall data exchange via an API and the provision of a dashboard for their cooperation partners to facilitate administrative processes of the smart parking systems, which is considered easy to handle (C8, PTO, AIR) and well suited for further data analysis (AIR, PSS). When asked about whether they analyze their data systematically, three of the cooperating partners (AIR, PSS, PTO) stated, "Yes, but we can't completely evaluate the data at the moment because it's not yet mature enough to work completely on its own" (PSS). However, the opportunity to gain information about end-user behavior is highly relevant for all cities and companies and a relevant factor for cooperation with AP3. In the next step, analyzing data systematically also makes it possible to steer end users, for example, by proposing alternative parking areas with lower occupancy. This feature is partly provided by AP3, as they provide real-time data on occupancies: "And when you talk about the issue, what does the citizen get out of it, […] then it's: I'm guided efficiently to a free parking space, that's the main point", but they do not provide forecasts on the expected parking situation based on the arrival time of end users (AP3).

At the **micro-level,** we find institutional arrangements for the cooperation motives and the pricing model foster overarching integration of the smart parking ecosystem, while the implementation process rather inhibits overarching integration.

Regarding the cooperation motives with cities, AP3 stated that their main added value is that "the city knows how busy its parking lots are. The city can manage parking traffic, both digitally and by putting up signs, and it can counterbalance traffic. There is no more traffic searching for parking spaces, and at the same time, of course, we also serve climate goals, CO^2 goals, if I have less congestion, less traffic, because the vehicles or the vehicle owners know exactly where they have to go" (AP3). For their cooperation partners, the main reason for cooperation varies widely: C8 uses the parking sensors for their e-vehicle parking areas, and for PTO, a public transport organization, the main reason for cooperation with AP3 is the use of sensors for P&R parking areas, to monitor and improve this parking service for public transportation users. AIR and PSS, however, are especially interested in the data-based and overarching service concept of AP3. AIR, for example, stated that they "[…] try to offer different digital processes for each customer—or for the different customer user groups," which includes payment services from other providers but also the data provided by AP3 to manage search parking traffic or to avoid congestions at highly frequented airport areas. Further, PSS uses the sensor data of AP3 to support its traffic management system with real-time data.

Regarding the overall costs, there is only limited information about the end user side, as AP3 is not a payment provider and therefore does not set prices for the use of the smart parking systems. The overall costs for the cooperating cities and companies are based on two components: a set-up fee, which includes "installation, provisioning of components, […] sensors, […] gateways, delivery and ensuring the system is completely functional" (AP3), and a monthly fee, which includes "the maintenance and upkeep and monitoring and the data itself" (C8) and depends on the number of sensors that are integrated into the smart parking system (AP3, C8, AIR, PTO). Overall, the institutional arrangements regarding the price model seem to be accepted by all involved actors because no cooperating company or city representative expressed a preference for a different pricing model or stated that AP3's prices were too high. Dynamic pricing based on the provided occupancy rates by AP3 is, again, not highly relevant in this ecosystem. So far, this feature is only used by AIR, although PSS expresses strong interest in this feature for future expansion steps of their smart parking systems.

AP3 considers itself a "full-service provider," which includes the organization and support of the implementation process. For three of the cooperating cities and companies (C8, AIR, PTO), the provided implementation by AP3 matches their perception of the implementation process, which is described as quick and uncomplicated. However, C8 and PSS stated that besides the technical implementation, the overall set-up of a smart parking concept is the actual effort: "Of course, what comes with smart parking solutions, [as] with anything digital, is always a high investment at first" (PSS).

4.4 Case Overview and Factors Leading to Specialized Smart Parking Ecosystems

Based on our detailed results of the interview data, we provide an overview of the main differences and similarities of each case in Table 2, also constituting the main mechanisms for value co-creation in each ecosystem. For Ecosystem 1, our results show that the focus of AP1 and the participating cities is on the provision of digital payment functionalities and parking guidance functionalities for the (potential) users. Similarly to that, AP2 and the cooperating cities in Ecosystem 2 co-create value by adopting digital payment functionalities. However, in contrast to Ecosystem 1, AP2 does not provide any additional services that include the collection or analysis of user or parking data. Last, Ecosystem 3 follows a data-driven approach, as they focus on data analysis for the provision of real-time data and provide the necessary infrastructure to collect the respective data points, such as sensors on parking lots. These differences in the value co-creating mechanisms also exemplify the main distinguishing features of the ecosystems, leading to specialized instead of overarching smart parking ecosystems.

Based on the main similarities and differences, we present various institutional arrangements that lead to specialized instead of overarching smart parking ecosystems in Table 3. Our results show that institutional arrangements at all context levels are relevant to explaining the emergence of specialized rather than overarching smart parking solutions in many cities or private parking areas.

At the macro level, the following institutional arrangements lead to specialized instead of overarching smart parking ecosystems. First, all three providers and many cities and other cooperation partners state that political arrangements hinder an overarching implementation of smart parking ecosystems, as either private parking areas are excluded from city park systems, there are regulations like equal treatment of citizens using and not using smart parking solutions, or municipalities are not willing to invest more money to reach better smart parking solutions. Second, we find that in all ecosystems, end-user preferences often conflict with smart parking solutions. In Germany, many people still heavily rely on cash payments, and older people are especially still struggling with smart parking solutions on their smartphones, leading to relatively low acceptance rates of existing solutions, which in turn inhibits the development of overarching solutions. Last, we find that in Ecosystem 1 environmental arrangements to promote public transportation instead of optimizing private car traffic is a hindering factor, while city representatives in Ecosystem 2 struggle with technical prerequisites for overarching solutions, i.e., comprehensive smartphone reception.

At the meso level, we first find that the provision of an easy, cost-effective digital billing process for cities and

Table 2 Overview of main similarities and differences in each ecosystem

Ecosystem 1	Ecosystem 2	Ecosystem 3
- Provision of digital payment functionalities - Provision of parking guidance functionalities on the street and in parking garages - Provision of tailored cooperation models for customers, including options for cooperation with public transportation companies - Provision of their own smart parking app - Overall aim: Offering overarching smart parking solutions for customers within their app	- Provision of digital payment functionalities - Focus on digital services (smart parking app) and exclusion of additional services like installing parking sensors, therefore exclusion of gated parking areas - No cooperation with other mobility companies - Provision of their own smart parking app - Overall aim: Provision of digital payment functionalities for a broad range of customers within their app	- Provision of real-time data (as API) - Provision of smart parking infrastructure like sensors - No focus on digital payment or billing functionalities - Strive for cooperation with other service providers within and outside the mobility sector - Overall aim: Providing an overarching smart parking service by offering APIs for existing apps instead of offering an own app

end-users in smart parking solutions fosters overarching solutions, while the absence of such services, like in Ecosystem 3, inhibits overarching ecosystems. Second, we find that smart parking data use and analysis fosters overarching solutions, while the absence of such services leads to specialized ecosystems. Data use can enable real-time information on accessible parking locations based on information provided either by users or by connected systems of cities, such as parking guidance systems. Moreover, data analysis can enable smarter recommendations for customers. For instance, parking data regarding the capacity of different parking areas on different weekdays or hours of the day can be analyzed to provide predictions for the expected time of arrival and, if necessary, supplemented with suggestions for other accessible parking areas.

At the micro-level, the following institutional arrangements can foster or hinder overarching smart parking ecosystems. First, we find that the motives of cooperation among the cities or other smart parking partners influence the resulting smart parking ecosystems. While we find that Ecosystems 1 and 3 aim at overarching solutions, including a plethora of smart parking services, our results also show that the restrictive data use and analysis of the provider in Ecosystem 2 can lead to several different cooperations, leading to several specialized instead of one overarching ecosystem. Second, attractive pricing models and low implementation costs of smart parking solutions lead to overarching solutions, as the cities and other smart parking partners are willing to continue the cooperation with the providers and are also interested in expanding the cooperation. On the other hand, a complex implementation process can lead to specialized solutions, as it hinders the expansion of smart parking ecosystems. Third, the additional effort that results from smart parking solutions can also hinder overarching solutions, as it can prevent cities from implementing these services for their citizens.

5 Discussion

Our results above show that many factors lead to specialized instead of overarching smart parking ecosystems. This can be attributed to a lack of 'smartness' in the current systems, which therefore fail to effectively address cities' environmental, economic, and social challenges with data-driven approaches (Gupta et al., 2019; Kar et al., 2019).

First, we find different views on smart entities, such as devices, socio-technical systems, and automated systems, as Alter (2020) defined, impede overarching smart parking ecosystems. For instance, our results show that especially older end-users struggle to use smartphone devices for digital payment of smart parking services. Regarding the socio-technical systems, we find that cities and end-users struggle with using their parking data, impeding smarter approaches to optimize parking services, and automated parking guidance systems are restricted by the minimal data use by some cities, especially in Ecosystem 2.

Second, current smart parking ecosystems do not meet essential capabilities (ubiquitous data, connectivity among objects, individuals, and organizations, and aggregation of information) characterizing smart technologies (Sharma et al., 2023). For instance, we find that representatives in Ecosystem 1 state that only certain parking areas are included in their current smart parking solutions. Ecosystem 2 is restricted by the lack of comprehensive cell phone reception. This leads to impediments regarding the provision and use of ubiquitous data and connectivity among objects and individuals (Sharma et al., 2023). Additionally, it restricts the aggregation of information, such as a comprehensive parking data analysis, to provide intelligent and contextual information to optimize parking search traffic with personalized parking suggestions (Sharma et al., 2023).

Additionally to these overarching factors defining what makes smart cities or smart mobility concepts smart, there are also specific functionalities that characterize what

Table 3 Overview of institutional arrangements for smart parking

Institutional arrangements	Ecosystem 1	Ecosystem 2	Ecosystem 3
Macro	**Inhibit integration:** - Political arrangements hinder the inclusion of private parking areas and higher investments in smart parking ecosystems - End-users prefer cash payment which is not suitable with smart parking solutions, and older people are not familiar with using smart parking services on their smartphones - Environmental arrangements aim at promoting public transportation instead of smart parking infrastructure	**Inhibit integration:** - Political arrangements target equal treatment of citizens using and not using smart parking solutions - End-users prefer cash payment which is not suitable with smart parking solutions, and usage rates of smart parking solutions are still low - Technical requirements for cell phone reception inhibit wider use of smart parking solutions	**Inhibit integration:** - Political arrangements inhibit a fast implementation of smart parking solutions with regulations, and municipalities do not actively steer cities towards smart parking solutions - End-users are often not yet aware of the added value of smart parking solutions, such as optimized parking search traffic
Meso	**Foster integration:** - Easy digital billing process seen as starting point for further smart parking digitization, additional service for end-users, and cost advantage for cities and end-users - Data use of traffic flows and update on usage rates of parking areas to reduce parking search traffic and navigate drivers to free parking spots **Inhibit integration:** - Limited analysis of parking data to ensure data security for end-users	**Foster integration:** - Digital billing process as cost advantage for cities and end-users **Inhibit integration:** - Minimal use and analysis of parking data to protect end-users, while many cities would prefer more smart functionalities, such as the steering of parking search traffic	**Foster integration:** - High degree of parking data use and analysis as the main selling point for many partners to enable smarter parking services for end-users - Provision of API enables low-cost and overarching smart parking solutions for cooperation partners with the possibility to integrate it into existing platforms **Inhibit integration:** - No provision of digital billing process by the provider as they do not offer their own app
Micro	**Foster integration:** - Cities' cooperation motives aim at implementing overarching smart parking solutions - Easy implementation process of smart parking solutions - Pricing model: Low overall costs for the implementation and operation of the smart parking solution **Inhibit integration:** - Checking smart parking tickets leads to additional effort for the cities	**Foster integration:** - Low implementation costs of smart parking solutions for cities - Attractive pricing model with low overall costs for the cities and no additional costs of smart parking services for end-users **Inhibit integration:** - Conflicting cooperation motives by cities can lead to cooperation with several smart parking providers - Checking smart parking tickets leads to additional effort for the cities	**Foster integration:** - Cooperation motives of partners aim at smart parking services to monitor and optimize their services for end-users - Attractive pricing model for the implementation and operation of smart parking services **Inhibit integration:** - Implementation process of the smart parking solution is partly received as complex and as a high investment by the cooperation partners

constitutes *smart* parking solutions (e.g., Hassoune et al., 2016; Saharan et al., 2020) that we find not fully evolved in our analyzed ecosystems. For instance, Hassoune et al. (2016) defined reserving parking spots and digital payment systems as important functionalities, or socio-technical systems, not embedded in all our analyzed ecosystems (Alter, 2020). Also, the ability to address environmental and social challenges with smart technologies is not fully exploited yet due to privacy and security concerns (Al-Turjman & Malekloo, 2019; Gupta et al., 2019; Kar et al., 2019), as former literature show that comprehensive smart parking systems can lower the drive-alone modal share, therefore contributing to the reduction of greenhouse gas emissions (Mangiaracina et al., 2017; Peng et al., 2017). Overall, we conclude that the current smart parking ecosystems in Germany show promising approaches to exploit the potential stemming from smart devices, socio-technical systems, and automated systems but still lack crucial development steps to fully transform parking into *smart* parking processes in the sense of a smart city.

5.1 Theoretical Implications

Our work has three main theoretical contributions. First, we complement the scientific literature on smart parking with an ecosystem perspective that focuses on factors that lead to the emergence of specialized ecosystems. While many papers take a predominantly technical perspective (e.g., Al-Turjman & Malekloo, 2019; Barriga et al., 2019; Idris et al., 2009; Perković et al., 2020), there is little research that examines how actors use the available technology. Based on our literature review, we also find that, with some exceptions (e.g., Chovani & Jokonya, 2019; Schulte et al., 2021), very few studies have been published in the IS field with a focus on smart parking – from either a technical or non-technical perspective. Accordingly, our study can be understood as a call for further research on this topic and its socio-technical aspects. Future research in IS can particularly build on the overview of the functions of the apps currently used for smart parking in German cities (Table 4) to highlight the gap between technical feasibility and actual use in practice.

Second, we contribute to the further development of the S-D logic perspective (Vargo & Lusch, 2004) by showing how institutional arrangements lead to the emergence of various specialized service ecosystems. The literature on the S-D logic perspective provides a limited understanding of how service ecosystems emerge and how actors, such as app providers, establish their position (Vargo & Lusch, 2017). However, it is assumed that "breaking, making, and maintaining" (Koskela-Huotari et al., 2016, p. 2964) institutional arrangements can facilitate value co-creation among actors, which in turn influences the emergence and design of service ecosystems. Although there is initial empirical evidence that conflicting institutional arrangements lead to actors not joining a service ecosystem (Schulz et al., 2023), it is still unknown how institutional arrangements lead to the emergence of different specialized service ecosystems as we observe them in practice in the field of smart parking.

Third, in the present study, we addressed this research gap by taking a multiple case study approach and analyzing three ecosystems that each focus on specific aspects of the parking process (e.g., digital payment, data analysis). In line with the S-D logic literature, we argue that context is important to understanding the emergence of smart parking ecosystems. Our results show how the different levels of the context – defined as micro, meso, and macro (Chandler & Vargo, 2011) – and the respective institutional arrangements (e.g., the low acceptance rate of digital payment in Germany) contribute to the emergence of specialized service ecosystems. For example, the limited political support by municipalities or state-level governments leads to limited financial possibilities for many cooperating cities to integrate more than one app provider into their smart parking ecosystem.

More specifically, we find that institutional arrangements at the macro-level (especially political arrangements and end-user preferences) often serve as a starting point for app providers, cities, and private parking companies for their targeted smart parking solution. For example, the low acceptance rate of digital payment in Germany leads to a specialization towards a data-driven business model for one of the app providers. This, in turn, influences the institutional arrangements at the micro and meso context level and leads to a lack of overarching smart parking solutions. Therefore, institutional arrangements at the macro level seem to be especially relevant for the degree of specialization of emerging smart parking ecosystems.

5.2 Practical Implications

Our work provides two main practical contributions. First, we provide an overview of the apps available for smart parking in German cities, which practitioners can use to advance along the path toward smart cities. Our overview shows that despite technical progress (development of sensors, big data approaches, etc.), smart parking apps still lack important functionalities in practice. For example, real-time data on occupancy is provided for only a small number of parking spaces, and forecasts of availability at the calculated arrival time are still problematic. In addition, the overview can also be understood as a call to practitioners to better exploit the potential of digitalization to address urgent problems, such as reducing parking search traffic to reduce air and noise pollution and thus make cities more environmentally sustainable.

Second, based on the interviews with cities and private parking operators, we can make recommendations to enhance smart parking solutions to promote their usage rates. Our results underscore the importance of matching app functionalities to user preferences from the customer's perspective. For example, in their study of the smart parking system in London, Peng et al. (2017) explain that public awareness, its usage, and user satisfaction are currently very low, which constrains the realization of its potential economic and environmental benefits. The user ratings for the apps that aim to enable smart parking in German cities also indicate a rather low level of user satisfaction (Table 4). However, the use of apps is of great importance for the enhancement of smart parking as many data-related functions, such as navigation to free parking spots, are only possible via app usage.

Our interviews with parking operators provide starting points for several potential improvements to smart parking solutions. Our results show that private parking operators (Case 3) better exploit data-related possibilities than most cities. The airport operator (AIR), for example, uses the possibility of dynamic prices to manage occupancy and increase turnover. One reason for this is certainly that cities are responsible for a much higher number of parking spaces, especially on-street parking spaces, which makes it time-consuming and expensive to equip the entire city area with sensors. Accordingly, one possibility to optimize smart parking solutions in cities would be to outsource the responsibility for the operation of parking spaces to private companies within a public–private partnership framework. Another reason is the non-digital mindset of many cities, which, for example, is evidenced by the need to affix a vignette or a handwritten note indicating the use of a smart parking app to the vehicle. Corresponding change management should be carried out in the cities to establish a suitable culture that focuses on the citizens and their growing interest in digitized solutions. An even higher orientation toward citizens' needs could be achieved if the data about parking occupancy were provided in overarching apps for cities that can also be used for other purposes, such as public transportation or to provide information about recreational facilities.

5.3 Limitations and Future Research

Our work has some limitations, which should be addressed in future research. First, we have limited our data collection to app providers and parking operators in Germany. As with residents of cities in many other countries, residents of German cities are negatively influenced by parking search traffic. The noise pollution and greenhouse gas emissions and other negative effects it causes negatively affect their well-being and health (Anenberg et al., 2019). From this perspective, our results are highly transferable. However, there are also some limitations to the transferability of our results. For example, people living in Germany have a lower level of acceptance of digital payment methods than people living in other European countries (EZB, 2021), which makes it difficult to reap the fruits of digitalization in general and smart parking in particular. To overcome this limitation, similar studies should be conducted in other countries to gain new insights into the emergence of specialized service ecosystems for smart parking through a cross-country analysis.

Second, in our analysis of the service ecosystem, we collected data from the app providers and parking operators but not from end users. In line with the S-D logic perspective, we assume that end users, for example, by providing data with their smartphone, are engaged in value co-creation and thus contribute to the emergence of specialized smart parking ecosystems. Future research should examine value co-creation in customer-to-business relationships to obtain a complete picture of the service ecosystem. One possible approach would be to analyze data from smart parking app user reviews and ratings on app store websites.

From a theoretical perspective, we have shown how institutional arrangements at the micro, meso, and macro context levels lead to the emergence of specialized service ecosystems for smart parking. Our study is grounded in recent S-D logic literature (e.g., Schulz et al., 2020; Vargo & Lusch, 2017), so we can assume that empirical evidence from the area of smart parking is sufficient to support the validity of our theoretical argumentation. Nevertheless, studies should also be conducted in other related areas, such as mobility ecosystems with public transportation and car-sharing providers, to examine the theoretical assumption about the effects of institutional arrangements on the emergence of specialized service ecosystems.

6 Conclusion

The use of private cars leads to numerous problems that negatively affect the population. Especially in cities, drivers looking for a free parking space contribute significantly to traffic volumes, leading to greater frustration, wasted time, costs, energy consumption, and noise and air pollution. Smart parking is one approach to reducing parking search traffic and the problems it causes. However, despite the existing technical possibilities, smart parking is still in its infancy, and overarching solutions for end users are lacking. In this study, we take a S-D logic perspective to theorize how institutional arrangements at the micro, meso, and macro context level result in smart parking apps being limited to certain functionalities (e.g., digital payment processes). To test our theoretical assumptions, we analyze empirical evidence collected in case studies with three service ecosystems aiming to enable smart parking in German cities and private parking areas. With our research, we use a theoretical analysis to tackle the practical problem of smart parking burdens in Germany, using insights from the scientific literature and practical insights smart parking industry specialists. By taking a socio-technical, and therefore interdisciplinary perspective, we unravel new insights including aspects from technical, behavioral, and economic research fields. Our results provide a theoretical foundation for the different factors leading to specialized service ecosystems. In addition, our results help practitioners to develop overarching smart parking solutions and advance along the path toward smart cities.

Appendix

Table 4 Overview of the app providers and their apps available for smart parking in German cities

App provider name	App name	Number of cities the app can be used	Number of app downloads	User rating	Core functions of the app
Ampido GmbH	Ampido	n.a	100,000+	4.6	Display of free parking spaces that are provided by private individuals, booking, digital payment, navigation
Cleverciti Systems GmbH	ParkPilot Köln	1	100+	n.a	Display of free parking spaces, navigation, digital payment (by forwarding)
EasyPark GmbH	EasyPark	> 2,200 cities in Europe	5,000,000+	2.8	Option to extend the parking time, charging per minute, digital payment
ParkHere GmbH	ParkHere Corporate	n.a	1,000+	3.8	Reservation of a parking space in a company's parking garage
ParkNow GmbH	PARK NOW	317	1,000,000+	4.6	Charging per minute, digital payment at the end of month
Parkster GmbH	Parkster	344	1,000,000+	4.4	Overview of parking spaces, option to extend the parking time, charging per minute, digital payment at the end of month
Smart City System Parking Solutions GmbH	CityPilot	n.a	500+	4.2	Display of free parking spaces
Stadtraum GmbH	mobilet.de	352	10,000+	2.4	Option to extend the parking time, charging per minute, digital payment
Sunhill Technologies GmbH	PayByPhone Parken	355	500,000+	4.0	Overview of parking spaces, option to extend the parking time, charging per minute, digital payment
SWARCO TRAFFIC SYSTEMS GmbH	PARCO	208	10,000+	3.5	Overview of parking spaces, option to extend the parking time, charging per minute, digital payment at the end of month
Yellowbrick GmbH	Yellowbrick Germany	101	5,000+	2.1	Charging per minute, payment of visitor parking fees, digital payment at the end of week

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Declarations

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