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Dynamic capabilities for ecosystem orchestration *A capability-based framework for smart city innovation initiatives*

Lina Linde[a], David Sjödin[a,e], Vinit Parida[a,b,e,*], Joakim Wincent[c,d]

[a] *Department of Business Administration, Technology and Social Sciences, Luleå University of Technology, SE- 971 87, Luleå, Sweden*
[b] *University of Vaasa, Vaasa, Wolffskavägen 34, 65200 Vaasa, Finland*
[c] *Hanken School of Economics, Helsinki, Finland*
[d] *University of St Gallen, St Gallen, Switzerland*
[e] *University of South Eastern Norway, USN Business School*

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ABSTRACT

Firms are faced with increased dynamism due to rapid technological development, digitalization, and sustainability requirements, creating novel opportunities for ecosystem innovation. This is particularly prevalent in smart city contexts where initiatives concerning, for example, energy efficient buildings and smart energy grids drive new kinds of ecosystem formation. Orchestrating emerging innovation ecosystems can offer a path to sustained competitive advantage for ecosystem leaders. Yet, it calls for the development of new capabilities to sense, seize, and reconfigure digitalization opportunities in a highly dynamic ecosystem environment. Yet, prior research lacks insights into the dynamic capabilities and routines required for ecosystem innovation. Therefore, this study investigates how firms can develop dynamic capabilities to orchestrate ecosystem innovation and, thus, gain from it. Through a multiple case study of smart city initiatives, we offer insights into the specific micro-foundations or sub-routines underlying the ecosystem leader's sensing, seizing, and reconfiguring capabilities, which are necessary to orchestrate ecosystem innovation. We develop a capability-based framework demonstrating three orchestration mechanisms – namely, configuring ecosystem partnerships, value proposition deployment, and governing ecosystem alignment. Our findings carry implications for the literature on innovation ecosystems and dynamic capabilities, as well as for managers.

1. Introduction

In the era of digitalization, innovation is a central concept that no longer resides at the micro level within the four walls of a company but rather at the macro level and across a multitude of partnerships called innovation ecosystems (Adner, 2017; Kummitha, 2018). Originating as a biological metaphor, the term ecosystem generally refers to a group of interacting firms that depend on each other's activities (Adner and Kapoor, 2010; Jacobides et al.,2018). Yet, there is little consensus on how firms can best organize the multitude of partnerships involved in ecosystem innovation. Firms need to be more dynamic because rapid technology development, digitalization, and the circular economy are creating increased industry convergence and large-scale industrial transformation. As a consequence, firms across industries are searching for new synergies, partnerships, and collaboration formats that can secure future competitiveness and profitable business models in an ecosystem setting (Furr and Shipilov, 2018; Kohtamäki et al., 2020; Parida et al., 2019). In particular, initiatives on smart and sustainable cities offer ecosystem opportunities for business-model innovation (Appio et al., 2019; Brock et al., 2019; Parida et al., 2019; Sjödin et al., 2020) by bringing together multiple diverse actors (e.g., energy and electricity providers, municipalities, construction companies, and citizens) in attempts to increase efficiency through novel multi-actor value propositions. However, current knowledge about how ecosystem leaders orchestrate extended ecosystems to profit in dynamic and uncertain environments is not well understood.

Across industries, we are witnessing numerous new business model initiatives by ecosystem leader, where they are adding digital technologies to physical products to offer so-called 'digital services' (e.g., optimization of energy usage in buildings) (Kohtamäki et al., 2020; Paschou, 2017). However, orchestrating innovation by leading actors in an ecosystem inherits several challenges. For example, orchestrating

* Entrepreneurship & Innovation, Luleå University of Technology, SE-971 87 Luleå, Email: vinit.parida@ltu.se+46 73 543 50 74
E-mail addresses: lina.linde@ltu.se (L. Linde), david.sjodin@ltu.se (D. Sjödin), vinit.parida@ltu.se (V. Parida), joakim.wincent@hanken.fi (J. Wincent).

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diverse actors such as municipalities, companies, and citizens (many of whom are new to each other, not having previously created and delivered value jointly), requires the proper alignment of diverse incentives among these new types of actor constellation (Sandulli et al., 2017; Visnjic et al., 2016). A further complication to the story is the new type of value proposition, such as digital services, tends to be new to the firm and their associated ecosystem. Value in an innovation ecosystem, compared to traditional value chains, is created, delivered, and captured differently, and it requires the alignment of activities among a diverse set of partners (Appio et al., 2019; Jovanovic et al., 2021; Parida et al., 2019). Ecosystem actors are dependent on each other's core competences to create and deliver value propositions. For example, a digital service such as the optimization of energy usage in a building requires firms providing the electricity, heating, and ventilation to work together to deliver the service to the customer.

A pivotal challenge for ecosystem innovation is that firms are not used effectively manage dynamic and uncertain ecosystem environments due lack established routines and capabilities for organizing ecosystem innovation in the digital era (Dedehayir et al., 2018; Sklyar et al., 2019). However, less is known about the type of capabilities required to remain competitive in these dynamic innovation ecosystem settings. Building on the resource-based view and the capability-based view (Helfat and Peteraf, 2003; Wernerfelt, 1984), the literature on dynamic capabilities can provide novel insights into how firms can manage highly dynamic external environments such as ecosystem innovation (Kindström et al., 2013; Lütjen et al., 2019; Shuen et al., 2014). Based on the idea that unique bundles of resources form the basis of competitive advantage, the dynamic capabilities perspective sees sustainable competitive advantage as the ability to create, extend, and modify valuable resources and capabilities over time Helfat and Raubitschek (2018). Such capabilities are arguably at the core of ecosystem innovation. Yet, insights into the formation and use of dynamic capabilities in an ecosystem context are hitherto lacking.

First, there is a *need for understanding how to develop dynamic capabilities and sub-routines that foster ecosystem innovation.* How can companies organize business processes to be able to continuously create and profit from ecosystem innovation? We argue that the theoretical lens of dynamic capabilities provides a relatively novel perspective from which to approach ecosystem innovation and build such important insights. There is, therefore, a need to understand the "distinct skills, processes, procedures, organizational structures, decision rules, and disciplines" (Teece, 2007, p. 1319) that underly dynamic ecosystem innovation capabilities. Indeed, few prior studies have investigated dynamic capabilities in an ecosystem context and, so, various gaps exist that need to be addressed. In particular, there is a need to understand the micro-foundational level Felin and Foss (2012) of how firms can develop routines to create and deliver new value propositions in collaboration with diverse ecosystem actors. Indeed, prior studies have described key challenges facing ecosystem innovation such as aligning incentives, deciding on roles, and formalizing governance mechanisms (Adner, 2017; Hurmelinna-Laukkanen and Nätti, 2018; Parida et al., 2019; Visnjic et al., 2016). Focusing on dynamic capabilities in an ecosystem-innovation context would provide opportunities for uncovering the productive routines and sub-activities that underly success in ecosystem innovation. For example, ecosystem leaders need capabilities that allow them to orchestrate multiple actors and leverage highly dynamic conditions (Parida et al., 2019).

Second, an interesting domain for further inquiry is *how ecosystem leaders can use dynamic capabilities for ecosystem orchestration*. How do different dynamic capabilities work together and what are the underlining orchestration mechanisms? For example, according to Teece (2007), dynamic capabilities can be disaggregated into three distinct activities: sensing opportunities and threats, seizing those opportunities, and maintaining competitiveness by reconfiguring resources. All three are critical if firms are to remain competitive in a dynamic environment. However, it would be beneficial to further investigate how ecosystem leader uses these different capabilities in combination for orchestrating relationships with diverse actors. Indeed, prior research has shown that distinct configurations of capabilities are required to successfully offer digital services in complex ecosystem (Sjödin et al., 2016). Extending such logics to the ecosystem-innovation context would provide important opportunities for understanding the basis of competitiveness that is derived from resources and capabilities in ecosystems.

Against this background, we focus on how dynamic capabilities can support firms to be competitive in an era of digitalization and increasing ecosystem innovation. Specifically, the purpose of this study is to investigate *how firms can develop dynamic capabilities to orchestrate ecosystem innovation.*

Our case study is built on data from 49 interviews from four ecosystems in the smart city context, where initiatives have been taken on smarter and more sustainable buildings and energy solutions. We have interviewed ecosystem leaders as well as customers, partners, and other suppliers participating in different ecosystems. The findings indicate that dynamic capabilities and, more specifically, sensing, seizing, and reconfiguring capabilities are crucial for ecosystem leaders to orchestrate the ecosystem and achieve ecosystem innovation in the long term.

This study has both theoretical and practical implications relating to ecosystem innovation, dynamic capabilities, digital servitization, and smart city ecosystems. First, it proposes a general description of dynamic ecosystem capabilities and their micro-foundations. Second, our study illustrates how ecosystem innovation is accomplished through the deliberate ecosystem orchestration through concrete mechanisms which leverage on the combination of dynamic ecosystem capabilities. We approach this from the perspective of the ecosystem leader and the orchestration of ecosystems. Third, contribute by empirical insights on the debate on the role of dynamic ecosystem capabilities for ensuring profitable smart cities initiatives.

Our paper is structured as follows. In the second section of this paper, we present the background to previous research on innovation ecosystems and dynamic capabilities, and their interconnection, with a specific focus on the smart city context. The third section provides an overview of our research methods including procedures for data collection and analysis. Our findings are presented in the fourth section of the paper and shed light on the sensing, seizing, and reconfiguring capabilities needed for ecosystem leaders to orchestrate the ecosystem and achieve ecosystem innovation. We conclude the paper with theoretical and managerial implications, and a final section reflecting on our study's limitations and advancing suggestions for future research into dynamic capabilities for innovation ecosystems.

2. Theoretical background

2.1. Innovation ecosystems: the case of smart cities

In recent years, both academia and practitioners have shown an increasing interest in the concept of 'ecosystem' as a new way to depict the competitive environment. While the term 'ecosystem' has been deployed in the field of strategy for some time (Dhanaraj and Parkhe, 2006; Iansiti and Levien, 2004; Moore, 1993), its applicability has greatly expanded over the last decade. Teece (2016, p. 1) even suggested that "the concept of ecosystem might now substitute for the industry for performing analysis". While similar terms such as networks and alliances (e.g., Gulati, 1999) are delineated according to actor ties, the pattern of connectivity for an ecosystem is the value proposition (Adner, 2017). Companies in an ecosystem rely on each other's contributions to a higher degree than in traditional value chains (e.g., Porter, 1985) where suppliers can more easily be replaced (Adner, 2017; Jacobides et al., 2018).

In their literature review of the strategy field, Jacobides et al. (2018) identify three different aspects of an ecosystem that scholars have focused on: business ecosystem, which centers on a firm and its environment; platform ecosystem, which considers how actors organize around a platform; and innovation ecosystem, which focuses on a particular innovation or new value proposition and the constellation of actors that support it. As with innovation ecosystems, smart city initiatives often require multiple (both existing and new) actors to come together and collaborate for a new innovative value proposition to take shape (Appio et al., 2019; Schaffers et al., 2011). Consequently, this is the perspective we adopt in this study. An innovation ecosystem can be defined as the "alignment structure of the multilateral set of partners that need to interact in order for a focal value proposition to materialize" (Adner, 2017, p. 42). This perspective considers the interdependence amongst ecosystem actors as value is created Adner and Kapoor (2010); it starts with a value proposition and seeks to identify the activities and set of actors that need to interact in order for the proposition to materialize.

The aim of smart city initiatives can be seen as "improv[ing] urban performance by using data, information and information technologies (IT) to provide more efficient services to citizens, to monitor and optimize existing infrastructure, to increase collaboration amongst different economic actors and to encourage innovative business models in both the private and public sectors" (Marsal-Llacuna et al., 2015, p. 618). Importantly, smart city initiatives involve significant ecosystem innovation activities as diverse actors collaborate to create novel value propositions so that the sustainability of cities is improved (Ahvenniemi et al., 2017; Appio et al., 2019). Ultimately, smart cities strive to increase the competitiveness of local communities through innovation while increasing the sustainability and quality of life for its citizens through better public services and a cleaner environment (Appio et al., 2019; Kumar et al., 2020). To achieve this, smart cities rely on innovation ecosystems leveraging state-of-the-art information technology (e.g., sensors and connected devices, open data analytics, and fiber-optic networks), as well as human capital (e.g., universities, companies, and public institutions) (Angelidou, 2014; Appio et al., 2019).

However, these ecosystems do not evolve on their own (Appio et al., 2019; Hurmelinna-Laukkanen and Nätti, 2018). An essential and distinguishing feature of an ecosystem is the presence of a central actor, who sets the system-level goal, defines the hierarchical differentiation of members' roles, and establishes standards and interfaces (Adner, 2017; Gulati et al., 2012; Teece, 2016). This leading role in the ecosystem goes under many different labels; for example, orchestrator (Hurmelinna-Laukkanen and Nätti, 2018), architect (Gulati et al., 2012), keystone player (Bosch-Sijtsema and Bosch, 2015; Iansiti and Levien, 2004), or simply ecosystem leader (Adner, 2017; Dedehayir et al., 2018). In the context of smart cities, the leader is the central actor providing more efficient services, encouraging the use of data and information technologies, and promoting increased value co-creation amongst different economic actors (Sjödin, 2019; Parida et al., 2019; Sklyar et al., 2019). The purpose is to encourage new business models in order to transform the smart city concept, and to maintain it. To orchestrate a smart city as an innovative ecosystem, the ecosystem leader needs to possess orchestration capabilities (Adner, 2017; Hurmelinna-Laukkanen and Nätti, 2018; Walrave et al., 2018). That means skills in forging and sustaining partnerships (Ginsberg et al., 2010; Li and Garnsey, 2013), managing technology infrastructure (Adner and Kapoor, 2010; Almirall et al., 2014; Gawer and Cusumano, 2014), governing the ecosystem (Adner, 2017; Visnjic et al., 2016), and managing value-creation and value-capture activities (Kapoor and Lee, 2013; Ritala et al., 2013). Verhoeven and Maritz (2012, p. 5) describe innovation ecosystem orchestration as "the set of deliberate, purposeful actions undertaken by a focal organization for initiating and managing innovation processes in order to exploit marketplace opportunities". Prior studies acknowledge that orchestration is a dynamic activity (Hurmelinna-Laukkanen and Nätti, 2018; Mitrega and Pfajfar, 2015; Teece, 2020), which is "a set of evolving actions, not static structural position" (Paquin and Howard-Grenville, 2013, p. 1624). To drive smart city initiatives, there is a need for central actors to address opportunities and threats, and mobilize ecosystem efforts around those opportunities by reconfiguring resources. Thus, the ecosystem leader needs skills and capabilities to orchestrate an innovative ecosystem – these are reminiscent of the dynamic capabilities discussed in prior literature but on a more aggregated level.

2.2. Dynamic capabilities for ecosystem innovation

How can firms remain competitive over time in an era of increased environmental dynamism? The answer that leading scholars have given is 'dynamic capabilities' (Eisenhardt and Martin, 2000; Kindström et al., 2013; Teece et al., 1997). The dynamic-capability perspective has its roots in the resource-based view (Barney, 1991; Schumpeter, 1934). But, whereas the resource-based view considers a firm's competitiveness through the resources and capabilities a firm already possesses, the dynamic-capabilities perspective focuses on how firms can adapt to changing environments by reconfiguring their resources and capabilities Eisenhardt and Martin (2000). While the dynamic-capabilities perspective has been criticized for tautologic reasoning and for being non-operational (e.g., Priem and Butler, 2001; Williamson, 1999), it has, nevertheless, become a cornerstone in the field of strategic management over the last two decades (Eisenhardt and Martin, 2000; Teece et al., 1997) because it provides insights into a very important competitive concern.

The dynamic-capability literature is based on the work of Teece et al. (1997), and Eisenhardt and Martin (2000). According to them, the underlying concept can be defined as "the firm's processes that use resources – specifically the process to integrate, reconfigure, gain, and release resources – to match and even create market change. Thus, "dynamic capabilities are the organizational and strategic routines by which firms achieve new resource configurations as markets emerge, collide, split, evolve, and die." (Eisenhardt and Martin, 2000, p. 1107). Research has acknowledged that, "when we observe a dynamic capability in use, we are observing the underlying processes" (Helfat et al., 2009, p. 31). Such processes include R&D, technology and/or knowledge transfer routines, alliance and acquisition capabilities, and resource allocation routines (Eisenhardt and Martin, 2000; Teece, 2007). In other words, dynamic capabilities incorporate the capacity to identify a need or an opportunity for change, formulate a response to such a need or opportunity, and implement a course of action (Helfat, et al., 2009).

Teece states that, for analytical purposes, "dynamic capabilities can be disaggregated into the capacity to 1) sense and shape opportunities and threats, 2) to seize opportunities, and 3) to maintain competitiveness through enhancing, combining, protecting, and, when necessary, reconfiguring the business enterprise's intangible and tangible assets." (2007, p. 1319).

Sensing capabilities is essentially about gathering relevant market intelligence. That involves being aware of the business environment and understanding markets and (potential) customers, competitors, and other ecosystem partners – in essence, identifying business opportunities Teece (2007). We are particularly eager to encompass this view within our research on dynamic ecosystem capabilities. These capabilities involve scanning, interpreting, learning, and creating activities Teece (2007), and are critical in developing innovative value propositions. The firm must constantly search, scan, and explore the full gamut of markets and technologies to identify opportunities and threats, and to understand latent demand (Helfat et al., 2009).

Seizing capabilities is about disseminating market intelligence; that is to say, addressing the identified business opportunity through an innovative value proposition Teece (2007). In an ecosystem, actors make use of each other's capabilities to address an identified opportunity and deliver the value proposition Teece (2020). In other words, complementarity in capabilities is essential for an innovation ecosystem and, often, it is the ecosystem leader who is responsible for orchestrating the resource flow (Dedehayir et al., 2018; Hurmelinna-Laukkanen and Nätti, 2018).

Finally, *reconfiguring capabilities* has to do with staying competitive over time by adapting resources and structures to changing environments Teece (2007). In an ecosystem, this can be a complex task because actors depend on each other's capacity to fully adapt. Thus, the ecosystem leader has not only to safeguard its own internal reconfiguring activities but also those of the ecosystem partners (Kindström et al., 2013; Teece, 2007). We acknowledge that dynamic capabilities exist in smart cities and, as they enable innovation ecosystems to continuously adapt and stay relevant, they become a source of sustained competitive advantage in rapidly changing, competitive, and innovation-intense markets (Eisenhardt and Martin, 2000; Kindström et al., 2013).

The field of dynamic capabilities provides a relatively new perspective from which to approach ecosystem innovation in general, and the smart city context in particular. So far, very few scholars have linked dynamic capabilities to ecosystem innovation. One emerging stream is exploring the role of dynamic capabilities in managing ecosystems for service innovation (Lütjen et al. 2019; Nenonen et al., 2018). For example, in their study of the energy utility sector, Lütjen et al. (2019) identify twelve ecosystem-related capabilities needed for service innovation in product-centric firms. Other scholars have focused on dynamic capabilities in more specific contexts. For example, Heaton et al. (2019) studied how dynamic capabilities can guide universities in managing their innovation ecosystem, consisting of industrial actors, and local and national governments. A few studies have focused on different aspects of dynamic capabilities for ecosystem leaders. Feng et al. (2019), for example, focused on the role of dynamic capabilities in helping start-ups to develop into ecosystem leaders, designing an evolutionary framework for the start-up process. Helfat and Raubitschek (2018) studied the potential of dynamic capabilities to increase value creation and capture for digital platform leaders and argued that innovation capabilities, environmental scanning and sensing capabilities, and integrative capabilities for ecosystem orchestration are critical for ecosystem leaders. These studies illustrate the relevance of dynamic capabilities in an ecosystem-innovation context driven by digitalization. However, we still lack insights into the composition and underlying routines that enable dynamic capabilities in an ecosystem-innovation context. In particular, sensing, seizing, and reconfiguring capabilities are arguably all required for firms to remain competitive over time and to find ways of applying diverse capabilities together. Yet, few studies have investigated their interdependence in reaching innovation outcomes.

Thus, new insights are required to understand dynamic ecosystem capabilities, the process of value creation from these dynamic capabilities, and the way in which the orchestration of ecosystems can facilitate a more comprehensive appreciation of how firms can best develop dynamic capabilities to profit from ecosystem innovation in smart city contexts.

3. Research methods

This study follows an exploratory multiple case-study approach to capture insights into how firms develop dynamic capabilities to orchestrate ecosystem innovation in smart city contexts. The case-study method is considered suitable when collecting qualitative and complex phenomenological data and addressing the 'how' questions (Eisenhardt and Graebner, 2007; Yin, 2018), which was the case with this study. Four innovation ecosystems were chosen, all pursuing smart city initiatives and creating innovative offerings for business-to-business markets. The cases were selected on the basis of three criteria. First, the case had to involve an innovation ecosystem; that is to say, multiple actors collaborating to offer a value proposition to the market. Furthermore, the case had to provide access to the ecosystem leader, a customer, and at least two other ecosystem actors (e.g., sub-supplier, technical provider, municipality). Second, the innovation ecosystem should be pursuing a smart city initiative, and the value proposition must be enabled through a digital technology – for instance, a digital platform to store, monitor, and optimize energy distribution. Third, all cases had to have an overarching goal to achieve sustainability benefits with their smart city initiatives; for example, to become more energy and resource efficient.

Of the four cases, two drive smart utility initiatives, and two drive initiatives on smart buildings. Three of the cases, Ecosystem 1, 3 and 4, can be considered successful in their smart city initiatives and innovation ecosystem efforts; each was able to develop a new innovative value proposition and create a viable ecosystem that could deliver it to the market. Ecosystem 2 struggled, however, never advancing further than meeting with potential ecosystem actors to discuss new offerings such as 'Indoor-Climate-as-a-Service'.

3.1. Data collection

Data was primarily gathered through in-depth interviews with individuals representing an actor in one of the innovation ecosystems studied. Interviews provide insightful information on how a phenomenon occurs Yin (2018). A total of 49 semi-structured interviews were conducted from September 2017 to October 2019 to understand how dynamic capabilities enabled ecosystem leaders to orchestrate an innovation ecosystem. The number of interviews per case firm (i.e., innovation ecosystem actors) varied because data and theoretical saturation was reached Bowen (2008); see Table 1 for further case information. The informants represented both strategic and operational positions and were selected on the basis of their knowledge and experience of the initiative as well as their accessibility. While a semi-structured interview protocol guided the conversation, the informants were given freedom to develop the discussion based on their competence, experience, and interest. The interview protocol included various overarching questions such as: *How do you search for new business opportunities? How do you create successful partnerships with ecosystem actors?* and *What sustainability benefits would [the ecosystem's specific value proposition] lead to?* This meant that, through only minor reformulation, the same aspects could be addressed with all kinds of ecosystem actors. Departing from the interview questions was permitted in order to explore particularly interesting aspects that emerged during discussion. Accordingly, the interview format was adapted throughout the data-collection process to capture the insights that emerged. During the interviews, detailed notes were prepared in addition to recording the interview and transcribing the audio file.

By applying multiple data-collection techniques, including interviews with multiple actors and a review of documents, we were able to triangulate our data Jick (1979). We performed document studies, reviewing company reports, project documents and agreements to provide context and validate our informants' views, thus enabling empirical triangulation. To increase reliability and enhance transparency, as well as the possibility of replication, a case-study protocol was constructed along with a case-study database. The database included documents, case-study notes, and analysis.

3.2. Data analysis

To understand how firms in smart city contexts develop dynamic capabilities to orchestrate ecosystem innovation, data was subjected to thematic analysis. Thematic analysis provides a means to effectively identify patterns in a large and complex dataset, as well as links within analytical themes (Braun and Clarke, 2006; Cenamor et al., 2017). The method follows an iterative series of phases to identify themes so that an empirically grounded framework can be developed from qualitative data Braun and Clarke (2006). Initially, we used insights from prior literature on dynamic capabilities to guide the formation of theoretically rooted overarching themes. To help us understand how firms orchestrate ecosystem innovation, we adopted Teece's (2007) division of dynamic capabilities – i.e., sensing, seizing, and reconfiguring – as synthesizing

Table 1
Innovation ecosystem cases.

Smart city initiative area	Ecosystem, focal value proposition, and city information	Ecosystem actors(# interviews)	Total# Interviews	Sustainability benefits
Smart Utility	Ecosystem 1 (E1): The control room of the city City in south of Sweden (128,000 inhabitants)	Leader: Energy provider (5) Customer: Municipality (1) Other actors: System and technology provider (4), Digital platform provider (2)	12	*Energy savings through reduced water leakages *Optimization of heat distribution through peak load analysis
	Ecosystem 2 (E2): Indoor Climate-as-a-Service City in north of Sweden (79,000 inhabitants)	Leader: Energy provider (6) Customer: Construction company/property owner (5) Other actors: Technology provider (1), System provider (1), Municipality (1), Digital infrastructure provider (1)	15	* Improved indoor climate (e.g., air quality) * Optimization of heat distribution to balance peak load
Smart Buildings	Ecosystem 3 (E3): Smart building services City in south of Sweden (963,000 inhabitants)	Leader: Property developer (5) Customer: Construction company/property owner (3) Other actors: Digital platform provider (1), Carpool provider (2), Laundry service provider (1), Caretaker (1)	13	* Attractive residents enabled by smart home solutions * Optimization of resources thanks to sharing solutions
	Ecosystem 4 (E4): Energy optimization service City in south of Sweden (128,000 inhabitants)	Leader: System and technology provider (5) Customer: Energy provider (1) Other actors: Municipality (1), Technology wholesaler (1), Construction company (1)	9	* Efficient energy usage through smart systems * Balanced heating thanks to energy accumulation in building
			Total 49	

concepts to create the three overarching themes; *ecosystem sensing capabilities, ecosystem seizing capabilities*, and *ecosystem reconfiguring capabilities*.

We then followed a process similar to the process for thematic coding presented by Braun and Clarke (2006), where initial codes based on reading transcribed data, notes, and secondary data were generated. Facilitated by MAXQDA software (version 2018.1), every interview transcript was read several times and, each time, phrases and passages related to the research purpose and overarching themes were marked. In total, we identified 13 codes, which represent activities that ecosystem leaders directed to orchestrate the ecosystem. The codes were connected to one of the three themes; for example, *directing ecosystem roles and responsibilities* and *establishing resource allocation processes* were considered activities performed under the theme, *ecosystem seizing capabilities*.

Through a series of iterations, we were able to discover links and patterns within the codes, which enabled us to group them into six sub-themes representing the ecosystem-leader routines that each coding activity was connected to. Jointly, these codes, sub-themes, and themes represent the data structure presented in Fig. 1. During the analysis process, the authors discussed preliminary findings with knowledgeable colleagues and industry professionals to arrive at valid results. In total, these steps enabled us to develop an empirically driven theoretical framework linking capabilities, routines, activities, and ecosystem benefits that emerged during data analysis.

4. Findings

This study seeks to investigate how leading firms can develop dynamic capabilities to profit from ecosystem innovation. By studying four innovation ecosystems and their smart-city initiatives, we find that

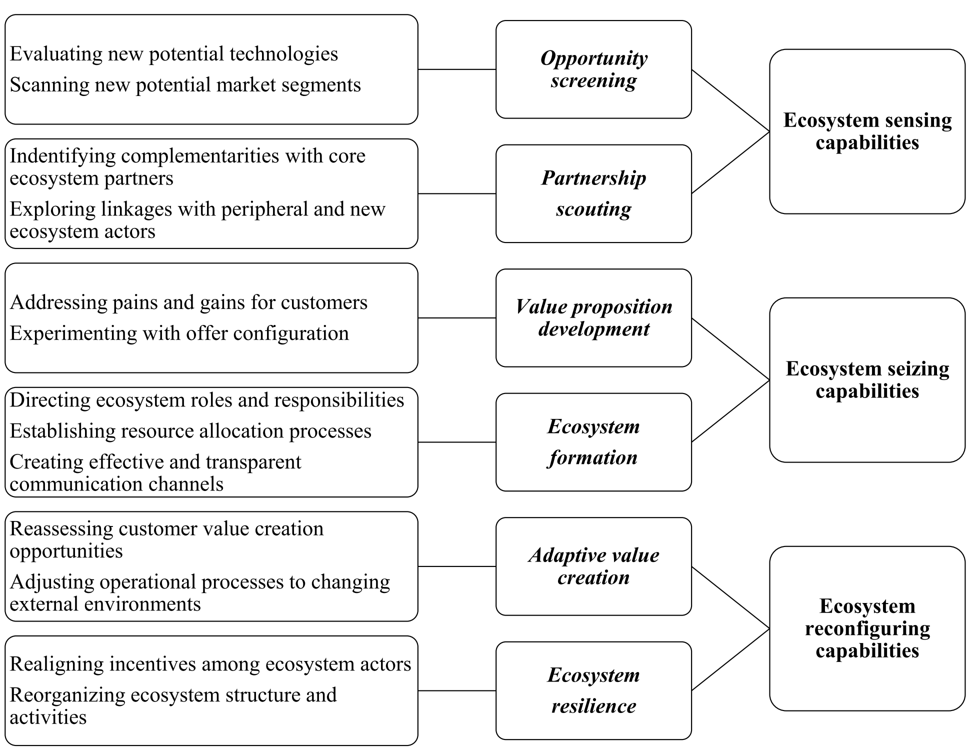

Fig. 1. Data structure: dynamic capabilities for ecosystem innovation.

Table 2
Representative quotations for each of the six sub-themes.

Sub-themes	Representative quotations
Opportunity screening	We want to systematically use our channels and connections out there, to scale up and find new opportunities – Ecosystem leader (E4) Change in our customer's [Ecosystem leader] business in relation to their customer has triggered this. We need to understand what we can do in terms of new solutions for them. So, we had several workshops to understand their needs. We had several visits inside and outside our organization to understand what they are looking for – System and technology provider (E1) [Digital platform provider] suggested a lot of interesting opportunities where we can connect new applications to their platform, for example, carpooling solutions and booking the laundry room – Ecosystem leader (E3)
Partnership scouting	We turned to both existing and new suppliers for help in solving this – Ecosystem leader (E1) We need to deliver full solutions instead, and then we need to acquire new competences inhouse, or outside our organization – Ecosystem leader (E2) We are working hard to sew it all together, all different actors… some might only have dialogue with us but, on many occasions, we need to gather multiple actors to achieve a finished offer – Ecosystem leader (E3)
Value proposition development	It could be the city, they would like to get the information about the pressure in the pipe that they can use for the fire department for example, and then they can have visualization of water pressure in the pipes to give guidance where to go and street work where they have restricted access to certain areas for example, and they are also trying to understand how they can sell their information to the house owners – System and technology provider (E1) We have all the technology available; we just need direction on what solutions to develop and what they [the ecosystem leader] want us to deliver – Digital infrastructure provider (E2) Together with [System and technology provider] we can come up with smart solutions that take us further with our common goal of contributing to a sustainable society – Energy provider (E4)
Ecosystem formation	And then, once the idea has been developed with key partners, we could go out to sub-suppliers and the whole ecosystem. – Ecosystem leader (E4) It is critical that we as leaders of these initiatives take an active role to drive in this direction, that we set the guidelines – Ecosystem leader (E4) That is the co-development and that should be free of charge for them [the customer], since they are putting in the same amount of time and effort to do that – System and technology provider (E1)
Adaptive value creation	We depend partially on [digital platform provider] to continuously develop and adapt the functions to respond to the customers' changing demands – Ecosystem leader (E3) There must always be continuity… we analyze the needs, adapt and develop solutions together with our suppliers – Ecosystem leader (E1) To be in the consortium requires something of you… you need to contribute so that the ecosystems continuously create value – Ecosystem leader (E4)
Ecosystem resilience	And then it is also the case that there is constantly new technology, new ways of thinking, new skills to incorporate – Ecosystem leader (E4) Our collaboration model requires us to continuously realign our incentives as we jointly decide on what development projects to invest resources in – Ecosystem leader (E1) To add and reconfigure the old ways of working is a huge challenge that hinders us from forming new partnerships – Ecosystem leader (E2)

ecosystem innovation is highly dependent on continuous adaptation to the evolving nature of customer needs, emerging technologies, and new entrants. Thus, having processes and routines that enable an adaptable organization to handle new market needs and requirements is necessary for innovativeness and long-term competitiveness. In this regard, we find that successful ecosystem leaders (i.e., case firms from E1, E3, and E4) develop dynamic capabilities in order to cope with the demands of ecosystem coordination and management. In contrast, the ecosystem leader in E2 that struggled to create a new innovative value proposition and viable ecosystem lacked capabilities such as complementary competence acquired through partnerships.

The analysis reveals that sensing, seizing, and reconfiguring capabilities, routines, and processes on the part of an ecosystem leader facilitates ecosystem-innovation orchestration through the joint process of value creation and capture with ecosystem partners. These findings build on the concepts of the microfoundations of capability Teece (2007) by identifying the formalized routines that underpin how firms secure competitiveness. In the following sections, we present our findings connected to sensing, seizing, and reconfiguring capabilities for ecosystem innovation. Table 2 presents representative quotations for each of the six sub-themes, prompting the need for the routines and their activities.

4.1. Sensing capabilities for ecosystem innovation

The study found that, for an ecosystem leader, sensing capabilities is related to an increased ability to scan more widely for new business opportunities. As they expand their businesses into smart city-oriented offerings, ecosystem leaders need to look beyond known ecosystem relationships and reconsider what offerings would be viable in this new business environment. For example, the ecosystem leader (system and technology provider) in E4 offered energy optimization services to energy providers as well as property owners. This meant that they had to configure a new offering with a radically new value proposition and initiate relationships with the energy provider, local municipality, technology providers, and service partners. In doing so, they opened up a new market segment and revenue streams that would be difficult to achieve without being proficient in scanning new business opportunities and being open to new ecosystem partnerships. As our findings illustrate, such capabilities are made up of systematic routines and subactivities relating to *opportunity screening* and *partnership scouting*, which are explained in the following sections.

4.1.1. Opportunity screening

As our informants' statements demonstrate, a critical part of sensing capabilities is initiating routines to screen for opportunities. This means having efficient processes in place to scan for opportunities that arise from emerging markets and technologies. *Evaluating new potential technologies* in the context of smart cities often requires ecosystem leaders to look outside their own firm's traditional portfolio of products and technologies. That is to say, there is no explicit link between probing technological possibilities and internal R&D. For example, ecosystem leaders were increasingly looking into the emergence of digitalization-oriented technologies such as big data analytics, machine learning, and AI applications. Thus, technology sensing seeks to identify interesting technologies that can facilitate the ecosystem's delivery of an innovative value proposition. Furthermore, ecosystem leaders that have carried this out successfully have cleverly made use of other ecosystem partners' sensing activities. For example, the ecosystem leader (energy provider) in E1 obtained insights from its control system provider about a suitable cloud solution that, after further exploration, paved the way to a platform for optimizing the energy grid. These joint sensing activities oblige other actors to share their ideas, which presents no difficulty when the conditions for an innovation ecosystem set-up make sense – in other words, when all actors benefit and need each other's resources in order to offer the value proposition.

When developing new value propositions driven by digitalization in an ecosystem, potential opportunities expand beyond current markets. Therefore, firms need systematic activities to *scan new potential market segment,* and target new kinds of customer. According to the system and technology provider in E1:

> "We are used to offering our product and services to utility providers but with the digitalization of our equipment, it suddenly became

> possible for us to offer value to the end customers. In this case, it was the municipality that was interested in having information about energy distribution as a part of a smart city control room that they were developing".

Thus, scanning for opportunities in an innovation-ecosystem setting requires a more holistic approach to identify opportunities beyond traditional markets and the internal competences that currently exist. Thus, the sensing activities provide the groundwork – the foundation – for what will later become the ecosystem's value proposition.

4.1.2. Partnership scouting

Given that the success and innovativeness of value propositions in smart city contexts are dependent on multiple actors, sensing capabilities are often dependent on formalized routines for partnership scouting. Thus, in order to facilitate an innovative and competitive ecosystem, it is of prime importance to identify the right consortium of partners that can jointly formulate a new value proposition. So, what makes suitable ecosystem partners? And how do you evaluate their worth, and how can they usefully be linked to the ecosystem? One important aspect of establishing robust partnerships is having routines to *identify complementarities with core ecosystem partners* in terms of competences and resources. For a partnership to make sense, there is a need for mutual dependence or, at least, mutual benefits. For instance, while an energy provider needs infrastructure and analytic skills to optimize the grid, system software providers need access to the energy grid to make use of its competence and create new digital offerings. Then, there is the example of the ecosystem leader (system and technology provider) in E4 that described a systematic mapping exercise they used with certain customers to see what they could provide and where ecosystem partnerships could be critical in meeting customer needs.

From the analysis, it became clear that, to build an innovative ecosystem, sufficient resources must be allocated to *explore linkages with peripheral and new ecosystem actors*. Informants explained how new partners can represent a fruitful source of innovation, unlocking new value propositions and revenue streams. According to the ecosystem leader (property developer) in E3:

> "Smart building services is actually a digital platform over which we can offer different digital services. We may be the provider of few critical services, but the real value of the platform is to create a possibility for other ecosystem actors to develop services for our building residents. For example, mobility services offered by a car leasing company can open a totally new kind of collaboration for us with new partners which was not possible before".

Thus, scanning beyond existing relationships using formalized routines represents an important precondition for developing smart city-oriented offerings.

4.2. Seizing capabilities for ecosystem innovation

Our analysis showed that, to fully realize the potential of the sensed opportunities, ecosystem leaders need to develop seizing capabilities. The ecosystem leaders that we studied had experienced substantial challenges when trying to translate an innovative idea into a vital value proposition, because this required them to create new forms of collaboration and interaction. For example, the ecosystem leader (property developer) in E3 had to reconceptualize the new digital value on offer to their residents beyond an attractive and well-functioning building. As they had a broad understanding of upcoming technologies, they decided to pursue a digital service strategy that built on platform thinking and opened up the platform to new partnerships. This entailed adding digital laundry services, mobility services, indoor climate services, among others. All of the new digital services under consideration were offered by new ecosystem partners with whom the propriety developer had no prior business relationship. Thus, much discussion and decision making was required to allocate roles and develop the joint offer. Although challenging, once successfully implemented, the result was an innovative and competitive ecosystem. As our findings illustrate, such capabilities comprise systematic routines and sub-activities relating to *value proposition development* and *ecosystem formation*. These are explained in the following sections.

4.2.1. Value proposition development

A key routine for an ecosystem leader is value proposition development. This involves forging the design of an attractive value proposition that the innovation ecosystem can deliver. Indeed, the value proposition is central to forming an ecosystem that can create superior value for customers. Thus, routines for *evaluating pains and gains for customers* are essential. These points are not always obvious when first contemplating new digital-service offerings. So, it is important to look deeply into different pain points and potential improvements for customers so that the most relevant can be earmarked for further innovation. The ecosystem leader (system and technology provider) in E4 explained:

> "We are not usually offering products and services to factory owners so, when they approach us, we are trying to understand what is the top priority for them. In this case, it is about having a carbon neutral facility. By having these insights, we could design and develop an offering which would be unique to their requirements".

For a new commercial or public building, there are many potential pains and gains to address such as energy optimization, smart transport solutions, and energy storage. However, the challenge is not just about identifying the differing needs, but it also requires the ecosystem leader (sometimes with help of other ecosystem partners) to identify which pains and gains to target, and then to connect the necessary actors to deliver the solution. Informants representing customer organizations explained how providers present them with value propositions directed at solving problems that are actually not on the customer's agenda. Consequently, they stressed the need for the ecosystem to better understand specific customer needs, and to explicitly target the pains and gains that a particular solution should solve. Thus, the ecosystem leader needs routines to *experiment with the offer configuration* – the actual offering and its subcomponents need to be clearly defined. A critical factor in this process is deciding on what can and should be done inhouse and which components and responsibilities should be outsourced to other ecosystem actors. As the value proposition is the central component in the innovation ecosystem, the ability to find actors that can provide the desired components and bundle them into an attractive and financially viable value proposition is key to the ecosystem's success. Alignment is achieved when the value proposition adequately addresses the customer's pains and gains. In other words, the value created by the ecosystem's offering needs to be high enough for customer(s) to be willing to pay for it. Informants stressed that aligning activities had become much more complex when they created new value propositions that involved many ecosystem actors. Some ecosystem leaders explained that this complexity had even made them consider taking on the role of ecosystem leader. The ecosystem leader (energy company) in E2 explained how they had experimented with many different routines in order to create a solid value proposition with their partners.

> "We do scoping workshops where we have to make sure that we are not just developing the 'good to have' services that don't produce the value because then we are wasting our time and our partners' time and commitment to digitalization."

4.2.2. Ecosystem formation

A common theme raised by the study's informants was the need to have structured routines for ecosystem formation. That is to say, routines were required to guide the kind of roles and responsibilities different actors exercise, to arrange the activities needed to develop the partnerships, and to ensure good communication. In speaking to successful ecosystem partners, we found that both providers and customers continuously stress the need for a leading actor to set the ecosystem's agenda and to *direct ecosystem roles and responsibilities*. The ecosystem leaders that we studied achieved this in different ways; several worked with a competence-based logic, which meant that actors were assigned roles based on the competences they had. For example, a service partner was responsible for maintaining customer interaction, while a technology provider was responsible for digital infrastructure development. In other cases, roles were assigned based on relationships, such as the level of trust between partners or previous experience of interaction with customers. The system and technology provider in E1 explained how this new trust in partners helped them develop new competences to make smarter investment decisions, apportion risks to a greater extent, and share aspects of the value-creation and delivery responsibilities.

In an ecosystem context, partners complement and make use of each other's tangible and intangible resources. And so, there is a consequent need for routines to e*stablish resource allocation processes* so that win-win situations are created for all ecosystem partners. In E1, the ecosystem leader (energy provider) created a team with a key partner in the ecosystem to jointly decide on a R&D budget and evaluate the best projects to which resources should be directed. Through these regular meetings and joint budgeting activity, the team was forced to prioritize between initiatives. Consequently, resources were allocated to projects that met the needs of both firms. As the innovation ecosystem demands close collaboration between some key ecosystem partners, many informants expressed a need to move away from transactional partnerships and initiate vested partnerships – that is to say, highly collaborative business relationships in which both parties are equally committed to each other's success. In practice, ecosystem partners agree on what (rather than how) each partner will bring to the value proposition. Also, the ecosystem leader (energy provider) in E1 explained how the pricing and cost models were changed to better balance the risk and reward between partners and, thus, create a better alignment of incentives.

Finally, a critical activity of ecosystem formation has to do with *creating effective and transparent communication channels* amongst ecosystem partners. Due to an increased focus on digitalization in the smart city context, the possibility of using the technology for increased transparency becomes feasible. According to the ecosystem leader (system and technology provider) in E4:

> "The demands on us to be clear and transparent towards our customers and suppliers has become critical. As the data flows between partners, it is evident that all parties will have better information about the engagement. Therefore, in many innovative projects, we are working with 'open book policy' and trying to focus on value-based pricing with customers."

The energy provider in E4 indicated that transparency is absolutely critical to their success and explained how this was one of the 'order winners' when choosing their technology provider (and consequently many of the sub-suppliers).

4.3. *Reconfiguring capabilities for ecosystem innovation*

Our study found that a key to sustained competitiveness and profitable growth is the ability to reconfigure resources and ecosystem structures as the actors evolve, and markets and technologies change. We are currently witnessing increased dynamism in the context of smart cities, where firms are challenged to renew their competences and structures so as to stay relevant and remain competitive. For example, in E1, a new technology enabled not just monitoring the district heating grid but optimizing the energy consumption and, thus, levelling peak loads. By being flexible and exploiting this new technology, the ecosystem leader (energy provider) was able to increase energy efficiency and find a new revenue stream from selling information to the municipality and providing blue-light functions that enabled the planning of maintenance and emergency routes.

Focusing on reconfiguring capabilities for ecosystem innovation is about ensuring evolutionary fitness for the ecosystem, its underlying value proposition, and the alignment structure among actors over time. To facilitate this, the case companies actively experimented with different approaches – for example, involving customers in R&D processes, or assigning joint ecosystem groups to work on innovation projects in order to maintain relevance. As our findings illustrate, such capabilities are made up of systematic routines and sub-activities relating to *adaptive value creation* and *ecosystem resilience*, which are explained in the following sections.

4.3.1. *Adaptive value creation*

Against the background of a highly changing external environment, informants stressed the need for routines that enabled adaptive value creation. That is to say, there must be continuous re-evaluation of what creates value for customers and what new opportunities technologies and markets can offer. Some of the ecosystems studied addressed this through regularly *reassessing customer value-creation opportunities*. Often, when digitalization maturity increases in the customer organization, new opportunities emerge that were either not contemplated or not considered possible previously. This opens up possibilities for new value creation where ecosystem leaders must cope with and adapt to the changing needs of customers. In case E1, the customer's pains and gains changed quickly as a consequence of improved knowledge on the available technologies, and a deeper understanding of what they could do, leading to new requirements for the value proposition. This obliged the system and technology provider to work closely with their digital platform partners and other system providers to continuously assess potentially new value-creation opportunities.

In all four of the cases studied, ecosystem leaders spent time on *adjusting operational processes to changing external environments*. As the ecosystem is constantly faced with new technologies and system upgrades, it is critical for the leader to ensure that its own competence is updated and that the various elements of the ecosystem are able to complement each other over time. The ecosystem leader in E3 described how this reality had been learned the hard way. They had to change their system provider because its technology lagged behind the competitor's innovative software and no longer satisfied customer expectations. In consequence, the firm developed routines for continuously assessing their ecosystem partners to ensure that their contributions remained relevant. In E1, the energy provider had solved this issue by adding contractual requirements for technology providers to ensure that they dedicated a certain amount of R&D resources to ongoing development of the software. In other words, they were able to provide the latest technology to customers. In both cases, failing to comply with the requirements would lead to either making necessary improvements within a certain time frame (sometimes with an associated penalty) or possibly lead to a change of ecosystem partner(s). The ecosystem leader (system and technology provider) described the importance of continuously adjusting the ecosystem to changing circumstances:

> "Things are changing rapidly right now, and we need to work together with our partners to ensure that we are able to adapt to new opportunities. What is value today will not be something customers want to pay a premium for tomorrow, so we need to have routines which enable us to always take that next step."

4.3.2. *Ecosystem resilience*

To stay competitive over time, routines to ensure ecosystem resilience are needed. This means proactive and continuous adaptations as the ecosystem evolves, new markets arise, technologies develop, partners leave the ecosystem, and new actors join. As part of the ecosystem's resilience routines, we find that ecosystem leaders are likely to spend considerable time on *realigning incentives among ecosystem actors*. Since the basic premise of value creation is changing, the contributions of different ecosystem actors may change, necessitating different revenue models and risk-sharing agreements. Continuously scanning for ecosystem synergies was viewed as critical in order to maintain complementarity amongst ecosystem actors. According to the construction company in E4:

> "As the construction industry is project based, often you have ongoing projects with the same partners in different configurations. Those partners that are able to cope with change and adapt are the most interesting to collaborate with in the long term as the business environment is highly dynamic, and we need to be able to develop resilience to change."

Furthermore, case companies described how they were *reorganizing ecosystem structures and activities* as part of their strategy to maintain competitiveness and innovativeness over time. In ecosystem E1, they ensured long-term competitiveness by creating joint ecosystem functions such as R&D teams. Other ecosystem leaders discussed potential mergers and acquisitions as a way of ensuring competences were relevant and of keeping up with the demand for emerging technologies. Common across all cases was the need to proactively reconfigure resources amongst ecosystem partners, either though closer collaboration (e.g., joint teams and risk sharing) or through dissolving unproductive collaborations and acquiring instead the competence inhouse or engaging a new ecosystem partner.

4.4. A dynamic ecosystem capabilities framework

Based on the inductive analysis, this research article proposes a capability framework to explain how ecosystem leaders apply dynamic ecosystem capabilities to mitigate the challenges of innovation ecosystems and realize sustainable innovation benefits in a smart city context. The proposed framework is grounded in the themes and dimensions identified in the empirical analysis. Whereas Fig. 1 reports the structure of the data, Fig. 2 depicts the relationships among the emerging constructs to create a dynamic ecosystem capability framework illustrating the interdependence of capabilities. It draws on the three components of dynamic capabilities – sensing, seizing and reconfiguring Teece (2007) – and illuminates the specifics of these components in an ecosystem innovation context. In particular, we outline and explain the sub-routines, activities, and abilities applied by ecosystem leaders to enable orchestration mechanisms for ecosystem innovation and ensure profits and sustainability benefits.

Overall, we identify three critical sets of dynamic ecosystem capabilities and their sub-routines. Each capability exercises a critical function in ensuring successful orchestration of ecosystem innovation for leading firms. The *ecosystem sensing capability* enables firms to identify novel business opportunities and potential ecosystem partners, in a world of endless opportunities thanks to digitalization. As our informants explained, it is critical to keep abreast of ongoing developments and seek inputs from other actors in a spirit of open innovation. While sensing capabilities focuses on identifying opportunities, the *ecosystem seizing capabilities* stimulate the ability to realize and exploit such opportunities through developing commercially attractive value propositions. This requires firms to disassemble and recombine the contributions of diverse ecosystem actors into a focal offering that creates value for customers. Furthermore, seizing ecosystem innovation facilitates the formation and development of a value-proposition-driven ecosystem to increase the competitiveness of both individual firms and the ecosystem as a whole. As informants from ecosystem leader firms indicated, there is a delicate balance between collaborating and competing, which must be maintained to facilitate viable and attractive ecosystems. The *ecosystem reconfiguring capabilities* ensure that the ecosystem is adaptive and flexible to changing external and internal conditions. Over time, this will secure the relevant value-creation and value-delivery features demanded by customers. Also, they provide the smart city ecosystem, whose roles and responsibilities are unclear, with the ability to reorganize its relationship structures and digital offering to better suit changed conditions, in the interests of long-term competitiveness. Thus, when these dynamic ecosystem capabilities are present, the whole ecosystem benefits because the leading firm is capable of managing the ecosystem in dynamic business environments.

A key insight from our analysis is that, in order to realize full benefits in terms of the long-term competitiveness and innovativeness of the ecosystem, all three capabilities and their separate routines need to be present and work jointly. The combination of all three dynamic capabilities enables the following three orchestration mechanisms. First, *configuring ecosystem partnerships* ensures that firms can direct their ecosystems to achieving evolutionary fitness through environmental changes. For example, combining dynamic capabilities can help a firm identify unproductive ecosystem partnerships that should be discontinued and locate new partnerships that will make the ecosystem stronger. Second, *deploying value propositions* ensures the development of new value propositions with ecosystem actors. Often, this means that value-proposition development is closely linked to ecosystem actor

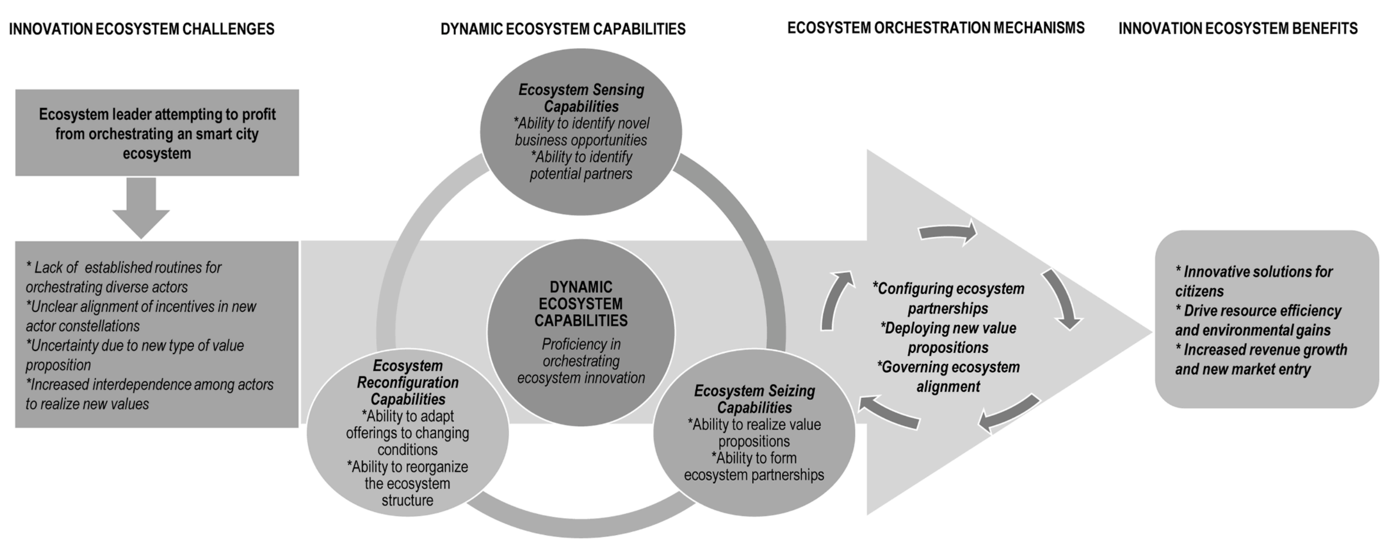

Fig. 2. A dynamic ecosystem capability framework.

involvement. The value proposition offered in certain ecosystem formations will, therefore, be very different from other ecosystem formations. Finally, the *governing ecosystem alignment* exercises the critical function of finding sustainable partnership configurations where complementary assets are shared and leveraged across firms, and benefits and costs are fairly distributed. A critical component is ensuring that ecosystem partners are incentivized to work for the common good and that their interactions in value creation are properly structured.

Evidence supporting why dynamic ecosystem capabilities are needed is indisputable because, during the early stages of ecosystem formation, the ecosystem leaders currently under study had failed in their initiatives from a lack of appropriate capabilities. For example, in E3, the ecosystem leader (property developer) had very good sensing capabilities but struggled to seize the opportunities that were identified since it lacked the critical customer connections needed to develop and maintain solid value propositions. On the other hand, informants affirmed the importance of sensing, seizing, and reconfiguring in E4, where ongoing evolution of the digital platforms required adaption of both the focal value proposition and the ecosystem structure as the initiative progressed.

The proposed dynamic-capability framework shows that the presence of these capabilities not only allows the ecosystem leader to orchestrate the relations but also produces significant sustainability benefits. Indeed, when sensing, seizing, and reconfiguring capabilities are present and interact, they promote sustainable ecosystem development and facilitate smart city ecosystem-innovation benefits. From the cases studied, we have noted that, when the ecosystem leader successfully develops and applies dynamic capabilities, the smart city ecosystems can accrue benefits. These include offering innovative solutions for citizens (e.g., remotely monitor and control the home), enhancing efficient and environmentally friendly use of resources (e.g., energy accumulation in buildings, levelling peak loads on the grid), and increasing revenue growth from new business opportunities and new markets (e.g., an energy provider selling infrastructure information on blue-light functions to optimize emergency calls). Thus, dynamic capabilities embody a core function that revises and reconfigures internal routines to meet the rapidly changing environmental conditions in a smart city context.

5. Conclusions

5.1. Theoretical implications

This research provides insights into how firms can develop dynamic capabilities to orchestrate ecosystem innovation. In doing so, it contributes to the emerging dialogue on dynamic capabilities and innovation ecosystem by extending the literature in four ways.

First, it contributes to the discussion in the innovation-ecosystems literature and *provides insights into the capabilities that ecosystem leaders need to be able to orchestrate innovation ecosystems*. Importantly, we find that the dynamic-capability perspective (Lütjen et al., 2019; Teece, 2007) is highly illuminating in expanding understanding of orchestration of the innovation ecosystem. Indeed, the dynamic-capability perspective has recently been given a significant boost in the ecosystem literature (Dedehayir et al., 2018; Feng et al., 2019; Lütjen et al., 2019; Teece, 2020). Our study adds to this line of research by providing evidence on how dynamic ecosystem capabilities and their corresponding sub-routines related to sensing, seizing and reconfiguration drive sustainability benefits. This micro-foundational view (Teece, 2007; Felin and Foss, 2012) on dynamic ecosystem capabilities has hitherto been lacking in the literature.

Second, this study contributes by *shedding light on how dynamic capabilities need to interact together* to achieve sustainability benefits. We demonstrate that individual capabilities on their own are not sufficient, but it is rather the combined use of the three sets of dynamic capabilities that helps ecosystem leaders to successfully orchestrate ecosystem innovation. Although the interdependence of dynamic capabilities is implicitly mentioned in prior literature (Teece, 2007, Eisenhardt and Martin, 2000), this perspective is often lacking in recent conceptualizations of dynamic capabilities (Kindström et al., 2013; Lütjen et al., 2019). We show that configuring ecosystem partnerships, value proposition deployment, and governing ecosystem alignment are key mechanisms for ecosystem leaders when using dynamic capabilities in combination*.* In particular, our research illustrates that failure to fulfil one or more of the dynamic ecosystem capabilities by leader firms was often the root cause of ecosystem-innovation failure. The interdependency, complementarity, and configurational logic of capabilities warrant further research in the literature (Sjödin et al., 2016).

Third, this article contributes by *illustrating the relevance of dynamic capabilities in a new empirical context i.e., smart city ecosystems*. By doing so, we show that dynamic capabilities are highly relevant in smart city ecosystems, and we explain how the specific activities and sub-routines play out when orchestrating such an ecosystem. Due to the rapid and unpredictable growth of digitalization and smart city initiatives (Appio et al., 2019; Marsal-Llacuna et al., 2015; Shuen et al., 2014), dynamic capabilities are vital for a firm's future competitiveness. Furthermore, this research makes a valuable contribution to the emerging dialogue in the empirical context of smart city literature, with specific reference to the capabilities that firms require in order to create and manage new and diverse forms of collaboration (cf. Dedehayir et al., 2018, and Kummitha, 2018). To this end, we present findings on how ecosystem leaders use dynamic capabilities, specific activities, and sub-routines to achieve ecosystem innovation.

Finally, this study contributes to an *understanding of sustainability benefits that cities can experience from ecosystem innovation* and, in so doing, encourages further initiatives of this type. Indeed, our case study demonstrates significant sustainability benefits – innovative solutions for citizens, a more resource-efficient society, and revenue-growth-generating business competitiveness – that arise from ecosystem innovation. Importantly, this research points to the likely determinants of successful smart-city innovation outcomes through possessing and using the three interrelated dynamic ecosystem capabilities. Thus, our findings add an extra dimension to the ongoing dialogue on sustainable and smart city developments (Ahvenniemi et al., 2017; Appio et al., 2019; Kumar et al., 2020).

5.2. Managerial implications

This study carries several implications for managers involved in ecosystem innovation and smart city initiatives. First, we demonstrate the importance of ecosystem leaders developing dynamic and innovative ecosystem capabilities and their underlying routines and acticities. Our study provides guidance to practitioners representing ecosystem leader organizations on the capabilities that are needed to orchestrate their ecosystems, and on the best way to organize business processes so as to promote ecosystem innovation and to profit from it on an ongoing basis. These relate to sensing, seizing, and reconfiguring ecosystems to take advantage of novel opportunities and to adapt in the face of dynamic environmental change. Our findings offer a mapping of key activities, routines and capabilities which need to be in place to orchestrate ecosystems. Second, digitalization and urbanization fuel smart city initiatives, which are being launched all over the world. Many smart city initiatives involve multiple actors (e.g., companies, municipalities, and citizens), that collaborate in novel ways – namely, in innovation ecosystems. Dynamic ecosystem capabilities lie at the core of orchestrating such collaborations. Finally, our results highlight the importance of maintaining a balanced approach to dynamic capability development. Rather than prioritizing one over the other, firms need to develop dynamic capabilities that are relevant across the dimensions of sensing, seizing, and reconfiguring if they are to profit from ecosystem innovation.

6. Limitations and future research

As with any research, this study has several limitations that needs to be considered when interpreting the results. For example, we gained only limited insights into unsuccessful cases of ecosystem innovation because a majority of the cases we studied (three out of four) were successful in creating a viable ecosystem that could deliver a new innovative value proposition. We were only able to make a very rudimentary comparison of successful and unsuccessful ecosystems. It is, of course, important in the context of furthering this research to contrast current successful cases with more unsuccessful innovation ecosystems. This would help bolster the evidence on whether the potential absence of dynamic capabilities acts as a hindrance to achieving ecosystem innovation.

Another avenue for further inquiry is to investigate how innovation ecosystems in other sectors – for instance, smart mobility or smart living (Appio et al., 2019) or other industrial settings – are working in practice, and whether dynamic capabilities are relevant to those ecosystems. In addition, it is likely that the dynamic-ecosystem capabilities identified will have important implications for the transformation inherent in digital servitization of manufacturing firms generally (Kindström et al., 2013; Sjödin et al., 2020; Kamalaldin et al., 2020) as ecosystems are increasingly important for service innovation (Lütjen et al. 2019; Sklyar et al., 2019) business model innovation (Linde et al., 2021) and in the context of digital platforms and autonomous solutions (Thomson et al., 2021; Jovanovic et al., 2021). For example, manufacturing firms offering digital services often govern new partnerships involving multiple actors (Paschou et al., 2017; Sklyar et al., 2019; Sjödin et al., 2019) and are, therefore, likely to benefit from dynamic ecosystem capabilities such as directing roles and establishing processes to allocate resources amongst ecosystem partners.

Finally, quantitative studies that investigate how dynamic capabilities at the level of the firm influence performance based on moderating variables such as ecosystem relationships, digitalization maturity, and other factors would add to the limited knowledge on what factors drive sustainability performance in a smart city context .

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Lina Linde is a PhD candidate in entrepreneurship and innovation at Luleå University of Technology, Sweden. Her research interests include servitization, digitalization, business model innovation, and strategic management. She holds an MSc in innovation and strategic business development from Luleå University of Technology.

David Sjödin is an associate professor of entrepreneurship and innovation at Luleå University of Technology, Sweden. He conducts research on the topics of servitization, advanced services, digitalization, process innovation, and business model innovation in collaboration with leading global firms and regularly consults with industry. He has published more than 30 papers in distinguished international journals, including California Management Review, Long Range Planning, Journal of Business Research, Industrial Marketing Management, and Journal of Product Innovation Management. He is the recipient of multiple awards, including the Entrepreneurship Forum Young Researcher Award 2018 for his research on the servitization of industry.

Vinit Parida is Professor of Entrepreneurship and Innovation at Luleå University of Technology, Sweden, and a visiting professor at the University of Vaasa, Finland. His research interests include organizational capabilities, servitization, business model innovation, digitalization of industrial ecosystems, and the circular economy. He has published more than 60 journal papers in distinguished international journals, including Strategic Management Journal, Industrial Marketing Management, Journal of Management Studies, Production and Operations Management, Journal of Cleaner Production, and he is an editorial review board member for Industrial Marketing Management and Journal of Business Research. He is the recipient of multiple awards for his research.

Joakim Wincent is Professor of Entrepreneurship and Management at Hanken School of Economics and Professor of Entrepreneurship and Innovation at University of St Gallen. His current research focuses largely on AI, machine learning, inter-firm and board relations, corporate entrepreneurship, and the influences of psychological constructs in entrepreneurship and management. He is also interested in measurement developments. His work is published in many journals including Academy of Management Review, Strategic Management Journal, Entrepreneurship Theory and Practice, Journal of Business Venturing, and Journal of Management Studies.