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EXPLORING DATA ECOSYSTEMS IN SMART CITY SERVICE CREATION

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Data platforms and data ecosystems play a key role in Smart City transformation, enabling data-intensive services and new value creation. As an emerging phenomenon, strategies, practices, and policies around data ecosystems are still forming. By utilising service-dominant logic and dynamic capabilities, this study maps out the roles and capabilities of cities in facilitating emerging data ecosystems, establishing data platforms, and identifying value proposals for data-intensive smart city services. We identify two main ecosystem leadership roles: business leader and innovation leader, their essential capabilities and activities that support establishing and growing a smart city data ecosystem.

Keywords: Data ecosystem; smart city; data platform; dynamic capabilities.

Introduction

Smart cities and smart city services are built and operated with data. Smart cities have been studied widely from technological, sociocultural, institutional and

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economic aspects (Zhao *et al.*, 2021) and basic concept of a "smart city" has traditionally included the use of ICT within the city services (Walravens, 2012). While advancing towards this concept, cities are in the midst of transforming their culture from corporate goveranance to platform governance (Perätalo *et al.*, 2022). In this process, data and data platforms play a significant role in the enabling and facilitating of co-creation of smart services (Anttiroiko *et al.*, 2014). A key element of a smart city is that it enables local innovation and co-creation, not only within the city organisation, but also with the citizens, local communities, and businesses as well as with research organisations. The smart city vision has evolved from technology and economy viewpoints to encompass people, governance and policies (Becker *et al.*, 2023). Innovative projects, proof-of-concepts and technology pilots are already an integral part of smart city operations but ramping those innovations up to truly innovative smart city services is not straightforward.

Technology, innovation and developing technical infrastructure are crucial for smart city development and fostering emerging technologies can offer new perspectives to value co-creation (Beverungen *et al.*, 2019). Among the enablers, data platforms emerge and smart cities become data ecosystems, where actors interact to exchange, produce and consume data (Oliveira *et al.*, 2019). As data ecosystems emerge around shared value propositions (Adner, 2017), understanding and establishing a city-level data ecosystem requires approaching the value co-creation from the standpoint of the city and it's actors, networks and resources (Curry, 2016; Kummitha, 2019).

The key question is how a city should stage a local data ecosystem, operate a data platform and related operations to enable smart services and local innovation as well as foster co-creation and what are the key capabilities needed to ensure the emergence of a successful, value-enabling data ecosystem.

Theoretical Background

A smart city is a sociotechnical system of systems: its people, technologies, businesses, organisations, and resources form a network of various actors. Smart Cities are under constant transformation where new actors and roles emerge, challenging traditional city policies and ways of working (Ekman *et al.*, 2019). The smart city transitions themselves are long-term urban innovation processes that aim to leverage digital technologies to improve the socioeconomic and ecological conditions in urban settings (Mora *et al.*, 2021). Smart city can also be approached as a systemic and collective intelligence that drives innovation through user engagement and large datasets (Anttiroiko and Komninos, 2019). Komninos *et al.* (2022) also argue that city smartness is systemic and emerges into

ecosystems as numerous projects converge. This study will view and refer to the city as an organisation that represents the collective system of city governance and various city operations.

Service-dominant (S-D) logic views all interactions and exchanges within an economy as service interactions. S-D logic takes a broad view of the value created by organisations, including the need to work with the market, customers, and other value-creation partners (Vargo and Lusch, 2004). Through the S-D logic lens, smart cities can also be approached as service ecosystems or smart markets (Ekman *et al.*, 2019). S-D logic offers a dynamic, continuing narrative for framing value co-creation (Vargo and Lusch, 2017). In the smart city context, S-D logic also supports the understanding of the contextual nature of city services (Anttiroiko and Komninos, 2019; Lusch and Nambisan, 2015).

The value of public services is tied to their context. Smart city value creation can be viewed from three settings according to the smart city ontology: (1) city, citizens, and activities, (2) the knowledge, intelligence and innovation activity and (3) technologies, smart systems (Anttiroiko and Komninos, 2019). This study will utilize the three key value creation settings of the smart city ontology in order to gain an understanding of the emphasis of smart city activities related to data, data-intensive services and their enablers.

Nenonen *et al.* (2018) suggest that dynamic capabilities explain further how key constructs of S-D-logic (value proposition, resources, and relationships) can influence service ecosystems, especially when it comes to the institutionalisation of ecosystem value proposals. Dynamic capabilities refer to organisations capability to sense opportunities and threats, seizing these opportunities and maintain competitiveness by transforming their business (Teece, 2007, 2018). In ecosystems, dynamic capabilities refer to abilities that are required to lead the ecosystem orchestration and management (Helfat and Raubitschek, 2018), ecosystem development (Lütjen *et al.*, 2019) as well as reconfiguration (Nenonen *et al.*, 2018).

Ecosystem sensing capabilities refer to the ability to gather relevant intelligence from the business environment – being able to constantly scan and explore the market, and technologies to identify opportunities as well as threats. *Ecosystem seizing capabilities* are needed for turning the market intelligence into action: Forming the ecosystem structure, testing, and delivering the value proposition. *Ecosystem reconfiguring capabilities* support the longevity of the ecosystem, enabling it to adapt its resources and structures to fit the changing market needs. Cities can be viewed as innovation ecosystem leaders who utilize these dynamic capabilities to orchestrate an innovation ecosystem (Linde *et al.*, 2021).

A summary of these high-level capabilities is presented in Table 1.

Efficient and true value co-creating will also benefit more from not only developing stand-alone applications, but mechanisms that facilitate resource

Table 1. Dynamic capabilities for ecosystem innovation (based on Linde *et al.* (2021)).

Dynamic capabilities	Sub-themes for capabilities
Ecosystem sensing capabilities	• Opportunity screening • Partnership scouting
Ecosystem seizing capabilities	• Value proposition development • Ecosystem formation
Ecosystem reconfiguring capabilities	• Adaptive value creation • Ecosystem resilience

integration (Anttiroiko and Komninos, 2019). Previous studies have indicated that digital platforms may help to facilitate resource integration between different parties on the platform (Hein *et al.*, 2019) as well as open innovation and entrepreneurship (Nambisan *et al.*, 2018).

Data platforms and publicly accessible datasets have been shown to facilitate innovation and co-creation of digital services – but their utilisation is hindered by the lack of coordination and co-operation in agreements (Mora *et al.*, 2023). Further challenges in establishing data ecosystems are, among others, building trust between actors, making the benefits of the ecosystem apparent, establishing agreements and standards and agreements on governance measures (Gelhaar and Otto, 2020).

Utilising S-D logic and dynamic capabilities, we explore cities in Finland and their approaches to facilitating smart city services, with an emphasis on the role of the city in enabling value co-creation in smart services.

Research Design

Our study aims to explore the role of cities in enabling data-intensive services, data platforms and eventually ecosystems beyond different proof of concepts and smart city initiatives currently ongoing. Our research question can be stated as *How can cities accelerate smart city innovation and smart service creation with data ecosystems?*

Data collection

Our research is an exploratory single case study combining smart city applications and services from the Finnish public sector. Both semi-structured interviews and workshops were used to gather insights related to future data-intensive digital

services in the smart city context from relevant stakeholders and to the role of the city in incubating these services. The interviews and workshops were themed around data-intensive services such as city digital twins and their enablers: data platforms, data analytics, data visualisation and data ecosystem activities such as policies and governance.

The empirical data was collected from four interviews with four organisations in Finland. Organisations included two Finnish cities, a city-owned urban development organisation and a large international technology provider company working closely with smart city service and data platform development. The interview participants were senior managers working with city information systems, city planning as well as data platform and digital twin development. The interviews were *key informant interviews* in nature. Key informant interviews offer a way to obtain in-depth information and insights within a limited period of time (Marshall, 1996). In addition to the interviews, researchers participated to development workshops in two organisations, a technology provider in mobility and asset management and a technology provider in urban mobility and innovative data. Combined, the workshops were participated by 40 stakeholders from various organisations.

Participants in the interviews and workshops are illustrated in Table 2.

A case study, being an empirical, in-depth study of a real-life context (Yin, 2003), supports the goals of the research and enables working towards the description and understanding of specific phenomena. Research was conducted by combining the data from the interviews and workshops, and by assessing additional qualitative data to increase the validity of the research data. The additional data was gathered from development projects relating to services utilising

Table 2. Empirical data for the study.

	Organisation(s)	Participants
Interview 1	City #1	1 Manager, city information systems
Interview 2	City #2	1 Senior Manager, city planning and zoning
Interview 3	City owned urban development organisation	1 Senior manager, digital twin development
Interview 4	Large technology provider company	2 Senior managers, data platform development
Workshop 1	Technology provider, mobility, and asset management	3 Senior managers, 15 specialists within single organisation
Workshop 2	Technology provider, urban mobility, and innovative data solutions	25 specialists, multiple organisations.

city digital twins and data platforms as well as from city-level data and innovation strategies from six large Finnish cities (Espoo, Helsinki, Tampere, Turku, Oulu and Vantaa).

The empirical data were initially coded with ATLAS software to identify individual Smart City services utilising an abductive approach, aiming to identify relationships between concepts. During the data collection and coding process, the initial drafts were reviewed by key informants to ensure data validity.

The results of the first coding round, total of 120 services or service concepts, were then selectively coded against the value creation settings (Konminos, 2016) to identify the focus and context of service concepts. The research design and process are illustrated in Fig. 1.

Data analysis

Findings of the second coding round: the city service concepts

The second coding round revealed three key themes for each value creation setting: collaboration-related service concepts, data-related service concepts, and research & development-related service concepts.

The three value creation settings are (a) the city as an activity setting, containing concepts like city, citizen, user and city infrastructure, (b) the city as a knowledge setting, referring to concepts like information, knowledge, intelligence and innovation and (c) the city as a technological setting, containing smart systems, urban technologies, networks and electronic services (Anttiroiko and Komninos, 2019).

For cities, citizens and activities, collaborative services aim to understand and improve current processes. The service concepts identified in the interviews were mostly related to the internal activities of organisations and aimed to facilitate more efficient collaboration between different divisions. The data-related services

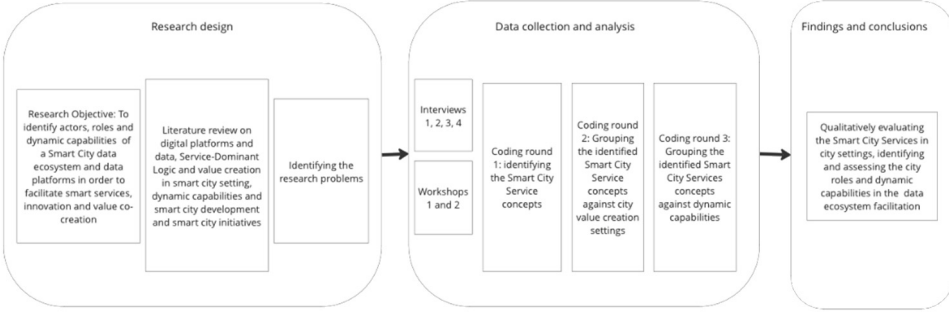

Fig. 1. The research process.

involved mostly different visualisation and sense-making either to city processes or forming a situational picture of the city operations. The research and development of services in this value creation setting is more focused towards developing identified, less experimental use cases.

For knowledge, intelligence and innovation activities, collaborative services support identifying innovation opportunities and networks that can utilize data. The data-related services relate to exploration and transforming data into novel information and the end goal is to find new dimensions, services and opportunities for value creation. Research and development-related activities in this dimension focus on creating new service opportunities and discovering new areas where data can improve performance, quality or give rise to new services.

For technologies and smart systems, collaborative service concepts relate to technology as a collaboration enabler. In the interviews, the development of data-intensive services and their enablers was seen as a key activity in establishing robust data practices, technologies and solid requirements that eventually lead to ecosystem-like activity. Value creation settings and the key activity themes are presented in Fig. 2.

Findings of third coding round: the dynamic capabilities

After the second coding round, the services were coded according to the dynamic capabilities. As data ecosystems are still an emerging phenomenon, the bulk of identified activities and capabilities are focused on the early stages of the ecosystem: sensing, scouting and formation. Experimental and innovative value proposition development is also heavily emphasized.

In ecosystem sensing, opportunity screening focuses on researching, understanding, and evaluating the possibilities of data, identifying possible data sources, and mapping out use cases. The activities involve internal and external parties that can either provide data as a resource, are possible service developers or users. Some services can also specifically support opportunity screening; these are related to marketing of the data ecosystem and especially the offering related to testing and piloting new opportunities related to data.

Partnership scouting focuses on building and identifying the network of stakeholders inside and outside of the city organisation. In this phase, the emerging data platform and ecosystem provide a context for defining and identifying collaboration around data. The partnership scouting activities include marketing, information sharing and collaborative interaction. Partnership scouting requires resources for not only establishing but also maintaining the collaborative channels.

In ecosystem seizing, the identified data ecosystem activities focus strongly on value proposition development. In the emerging city data ecosystem where

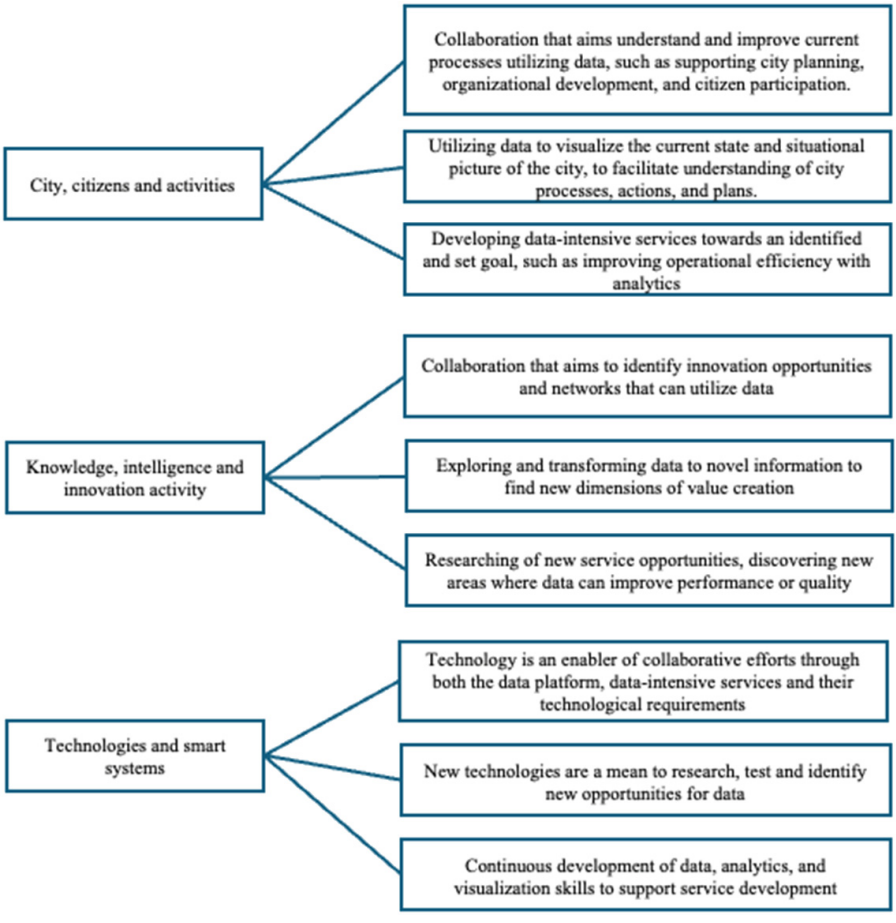

Fig. 2. City value creation settings and aggregated key activity themes.

the ultimate focus is to offer smart services, value proposition development is highly experimental. The studied service concepts specifically tested ways to utilize data for building a better situational picture, supporting decision-making, developing and testing different scenarios, gain totally new information, and developing the very understanding about the value expectation of data.

The ecosystem formation in the emerging city data ecosystem consists of activities that make the ecosystem more constant. It involves setting the first sets of rules to the collection of data, defining data models and practices, building data catalogues and documentation. It also has a strong collaborative element; the network around the collaboration becomes more stable, participation and roles in the community are more clarified, and there is a better understanding of common goals.

The adaptive value creation in the city data ecosystems focuses on accelerating the data-related value proposals and expanding the technology stack. Most service concepts that could be coded as adaptive value creation were conceptual iterations of what the services and value that they provide could be in the future: what kind of new information could be derived or what possibilities new technologies like AR, VR and more advanced use of AI bring.

The ecosystem resilience in the city data ecosystems consists of activities to solidify the data platform and the ecosystem around it as a constant part of the city functions. When the data practices evolve, the data platform becomes more than just an enabler technology and the surrounding ecosystem can start to form links to other ecosystems. Ecosystem resilience also relates to activities that support regional vitality. The dynamic capabilities, their related activities and their link to value-creation settings are shown in Fig. 3.

Findings

All the presented dynamic capabilities are needed to sense, seize, and reconfigure an ecosystem. Differences in context and contextual goals, however, cause the emphasis of activity to vary. Based on the analysis of the service concepts, the emphasis of the activity on city data platform and ecosystem activities can be on either *business leadership* or *innovation leadership*.

Partnership scouting, ecosystem formation and *ecosystem resilience* can be defined as more prominent business leadership capabilities. Innovation leadership capabilities in turn focus on *opportunity screening, value proposition development* and *adaptive value creation.*

Business leadership capabilities aim to improve the vitality of the city or the region by building, facilitating, and developing opportunities for (especially local) businesses. In data ecosystems, this means providing access to datasets, supporting recognition of new business opportunities, and bringing companies together in the ecosystem. The city as an ecosystem lead can also assume a stronger position in directing the ecosystem rules, responsibilities and roles, utilising and implementing national and EU-level policies and regulations.

Regarding *partnership scouting*, the interviewees pointed out the constant need to market, spread knowledge, and create interest in common data activities and expand the potential base for collaborators. The need for active collaboration is widely recognized but identifying the right actors and resources as well as is seen as a constant learning process that requires resources. In partnership scouting, key activities and responses of an ecosystem facilitator also include understanding and evaluating the key abilities of the other ecosystem actors, identifying new relevant actors and connections in the process. This can also

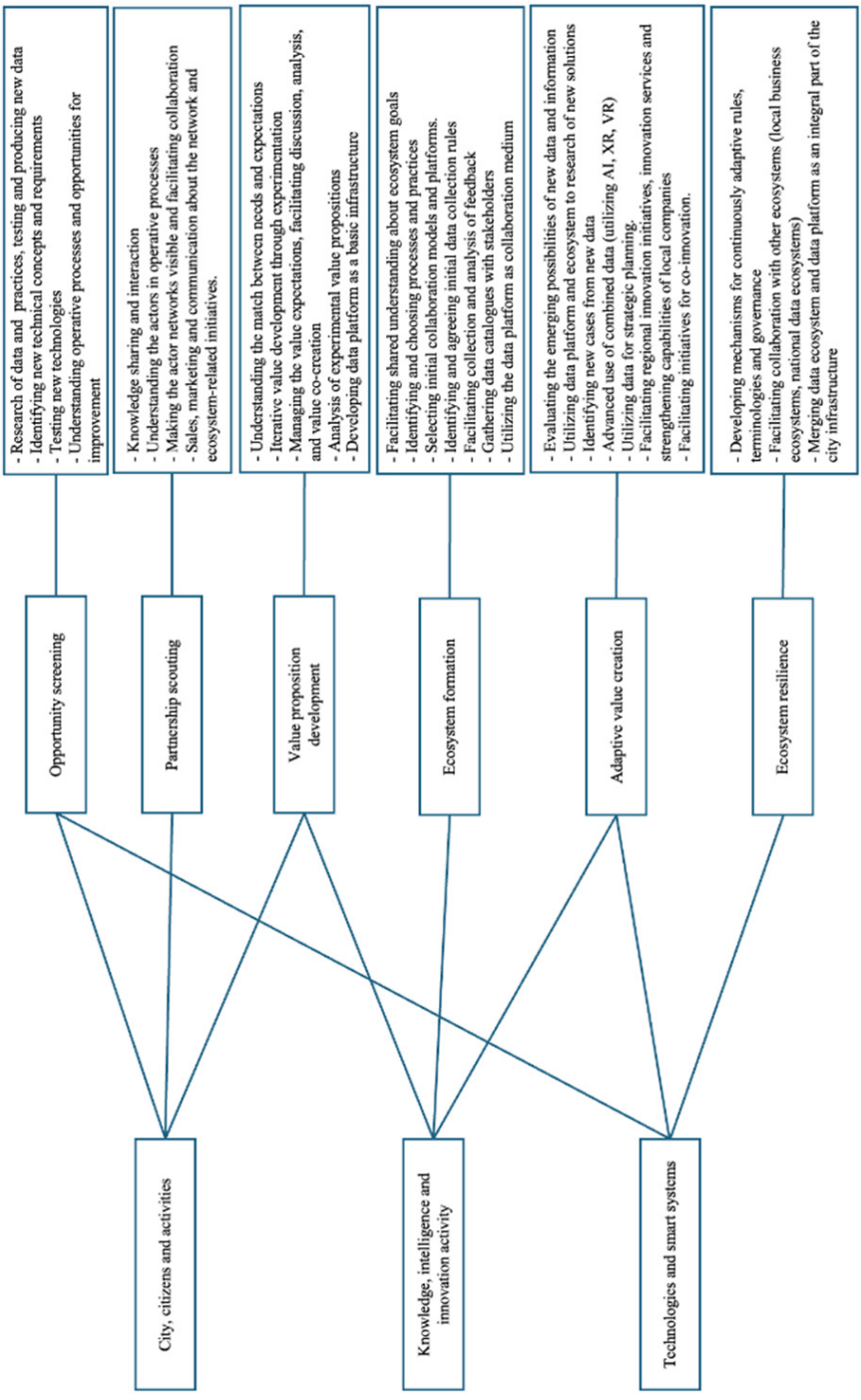

Fig. 3. Value-creation settings and dynamic capabilities.

include marketing and promoting the network or data ecosystem in relevant partner networks.

In *ecosystem formation*, interviewees highlighted the need to establish shared rules, data models and a shared understanding about data platform or ecosystem goals. The need for technical groundwork is substantial and cities as well as other public authorities are seen as key players in enabling data ecosystems and indeed data economy. Especially in data ecosystem and data platform, the technical solution itself plays a big role. The ecosystem formation also encompasses a wide array of data-related rules and practices, such as gathering data catalogues, establishing accessible technical documentation and the infrastructure for communication. Interviewees pointed out that pilot and proof of concept-driven development would benefit from systemic, long-term goal setting and focused approach when the aim is to develop more permanent smart city services and not just "try out technical things". In ecosystem formation, key activities of a business leader ecosystem facilitator can include facilitation of creating agreement on collaboration models, data-related rules and codes of conduct, but ecosystem facilitator can also assume a more directive approach and set at least an initial set of rules and practices from their point of view, supporting and conforming for example city data strategies.

Ecosystem resilience-related activities were not yet observed widely, most likely due to the nascent nature of the platforms and ecosystems. Interviewees noted, however, that ecosystem-related work, as city data activities overall, should serve a long-term, strategic purpose — increase vitality and innovative capacities of the entire region and even nationwide. Data platforms and their technical infrastructure are becoming a crucial part of a Smart City infrastructure and the operative models around them are expected to do the same. A business leader can advance ecosystem resilience efforts by supporting, promoting, and facilitating continuous improvement and adaptation of rules, governance, and ways of working. Business leaders could, for example, take responsibility for evaluating evolving regulations and provide clear guidance for other ecosystem partners.

Innovation leader capabilities improve the essential conditions for local and networked innovation activities. Innovation leader activities include evaluation and pilot programs that focus on testing the possibilities of new technologies, new value propositions, and seeking functional relationships between stakeholders.

Opportunity screening in city data ecosystems includes a significant research element: interviewees mentioned the constant need to not only gather but study the data itself, having an agile mindset and capability to test out new technologies with low thresholds. It's worth noting that even when talking about potential smart city services and their use cases, the interviewees clearly emphasised the strong technical dimension related especially to new ways of information visualisation

and analytics. Opportunity screening can also include scouting and evaluating new technical partners and identifying funding instruments and opportunities. Opportunity screening also includes research into the operative processes of the city itself in order to identify opportunities for improvement.

Value proposition development is at the heart of city data platform and ecosystem activities. The interviewees identified numerous potential value streams and expectations for data-intensive applications and smart city services are high. The value expectation varies from gaining a deeper understanding of the city's situational picture to creating predictions and scenarios for strategical decision-making. Value proposition development has a highly innovative element and the city data platform is seen as a valuable resource to support also local innovation activities. Value proposition development is essentially the search for use cases and services that create the most value and serve the needs of the evolving city. According to the interviewees, this also encompasses iterative development and participation of several stakeholders and the city as an ecosystem lead could provide neutral, future-oriented space for such discussions.

Adaptive value creation maps the future of innovative data-intensive services that utilize and further develop the city data ecosystem. In the interviews, the data platform and related activities were seen as a crucial enabler for regional innovation, benefiting from new technologies such as AI and even in democratisation of innovation. The city as a data ecosystem provider could boost and steer the way of local innovation and ensure equal opportunities for various actors. Adaptive value creation also supports the longevity of the ecosystem: Because cities, technologies and value expectations are continuously evolving, the ecosystem should have the ability to continuously identify, evaluate and test new dimensions of value creation. An innovation ecosystem led by a city can also facilitate regional innovation initiatives and create opportunities for wider co-innovation.

Contribution and Practical Implications

For innovation management in a smart city context, the study highlights the two different innovation management roles for the cities: Innovation and business leader. These roles are entwined into the governance aspects of data platforms and value co-creation capabilities of the ecosystems based on digital platforms. Our study provides insights into these main roles and the innovation capabilities of cities. Theory building was not the main intention of the study, but rather investigate the phenomena of data platforms and ecosystems in a practical setting. The small sample size also adds to the limitations when it comes to the generalisation

of the findings. Future research avenues could analyse the role of actors and resources and their effect on the emphasis on dynamic capabilities.

Observing the city data ecosystem through S-D logic as a service ecosystem enables identifying key activities related to value co-creation in specific value settings of the city. The dynamic capabilities in turn explain further, what type of activities and emphasis data ecosystem facilitation needs in order to develop and mature. The identified roles furthermore have an impact on the different services pushing the smart city development forward. In addition, our findings add to the understanding of the value creation across different industries, increasing in their part the generalisability of findings such as Hein *et al.* (2019).

Practical implications

For innovation managers working with smart city innovation clusters and managers in city organisations, the study provides insights into the development of the role of the city in data platform development. We propose that when aiming to facilitate the creation of innovative, smart city services, cities should take an active role in developing and providing more than just the enabling technologies. This facilitation can be geared towards business (business leaders). or innovation (innovation leader).

The business leader focuses on enabling the continuation of smart services where an innovation leader leans more towards utilising and learning about new technologies and possibilities for value creation. It's essential to point out that there is no need to make a one or the other-type choice between these positions — business and innovation are in incessant interaction and innovation activities typically aim to evolve into business activities. Cities should, however, pay attention to how to steer activities with appropriate capabilities and evaluate what the true objective of each data-related smart city initiative is. Business and innovation leaders' key goals, capabilities and responsibilities related to them are shown in Table 3.

Business leader capabilities

In the forming phase of the data ecosystem, the business leader focuses on establishing a collaborative network of various actors. Several Finnish cities have active business networks that are operated by cities and through their existing ecosystems, cities have strong sense about the needs and possibilities in their area. A business leader city in a data ecosystem can identify, contact and manage collaboration between stakeholders from businesses to research institutes to citizens, in other words, support *partnership scouting*.

Table 3. Business and innovation leader goals, capabilities and responsibilities.

	Business leader	Innovation leader
Key goals	Improving the local vitality, supporting the creation business opportunities, and facilitating business activities.	Improving and supporting the local innovation capabilities, providing means, platforms and collaborative structures for innovative value creation.
Key capabilities	Partnership scouting Ecosystem forming Ecosystem resilience	Opportunity screening Value proposition development Adaptive value creation
Key responsibilities	Establishing ecosystem goals, collaborative models, processes, and practices. Communication and promotion of the ecosystem and the network.	Identifying opportunity areas for innovative value creation, establishing the foundation of innovative networks to form. Identifying and organising funding opportunities.

In addition, business leader can assure facilitation and rule setting for co-ordination and collaboration practices, improving possibilities to foster service creation in the ecosystem in *ecosystem forming*. As some interviewees stated, a city is a logical neutral actor and therefore can act towards a common good, offering equal opportunities to many types of businesses and especially helping small, local businesses in their value creation. As a practical example, Tampere University of Applied Sciences is establishing an Urban Data Playbook for the City of Tampere, aiming to provide local businesses with a clear and understandable guide for utilising data (Collaboratively Smart City project Tampereen korkeakouluyhteisö, 2024).

Finally, a city as a business leader in a city data ecosystem, could give a significant contribution to *ecosystem resilience*: In addition, on establishing the governance and practices around the data activities, cities have a possibility to guide the regional ecosystem according to city strategies and support initiatives that serve local business ecosystems. Moreover, a city as a neutral actor has also the possibility to ensure that new technologies, such as AI are being utilized in a sustainable and ethical way. For example, City of Helsinki has established an AI register. The register serves both as a transparent catalogue of the city's AI initiatives, but also hopes to support and encourage citizen participation in AI development by offering understandable information about AI and its usage (Haataja *et al.*, 2020).

Innovation leader capabilities

In general, Finnish cities work actively with innovative initiatives, research, and pilot projects. The largest cities have established their own innovation accelerators, that are tasked with acceleration of smart city and local innovation initiatives. This supports especially the ecosystem forming stage and *opportunity screening*. In the City of Helsinki, Forum Virium Helsinki facilitates pilot projects, organizes funding, and facilitates data practices as well as local co-creation practices (Forum Virium, 2024).

As a neutral actor, an innovation leader city can support local innovation activities by offering data platforms, data sets or data marketplace as a service, possible for a lower cost than market-driven alternatives. This enables local research institutes, especially smaller companies as well as educational institutes to utilize city data to their innovation activities and engage in *value proposition development*. City of Kuopio has established a data platform (Datajalostamo), that aims to support horizontal value creation in transparent, neutral setting. It offers various degrees of public data for research institutes, educational institutes, companies and city organisation as well as an opportunity to share completely new datasets with other users ("Datajalostamo Kuopio," City of Kuopio, 2024).

Capabilities supporting *adaptive value creation*, strategical development and long-term goals are also needed in innovation leadership. Some interviewees stated that when seeking long-term value and established services, it's not enough to just offer a technical infrastructure and data, but provide support, standards, and practices as well as means to converge and exchange information. This observation is in accordance to that of (Komninos *et al.*, 2022), who state that "*smart city evolves from the execution of specific projects to the implementation of plans and strategies through which it becomes possible to tackle wider challenges; it becomes necessary to develop strategies that articulate projects to achieve a holistic and comprehensive city-wide change*".

Both leadership positions require value co-creation and a horizontal approach to data, powered by data platforms and their technological and organisational infrastructure. As seen in Fig. 3, the observed city capabilities have a slight emphasis on *Ecosystem Sensing and Value creation* phases: partnership scouting and especially technology-driven opportunity screening as well as value proposition development and adaptive value creation. At the same time, ecosystem resilience capabilities are not yet as prominent. This could echo the emerging nature of city data ecosystems, but is an indicator of capabilities that need more attention in order to mature and build ecosystems that have longevity and that are resilient to change, should it arise as technology evolution or changing regulative frameworks.

By carefully positioning the digital platforms, enabling data sharing, establishing rules of operation, and creating possibilities for collaboration the cities may have an opportunity to support resource integration and value co-creation capabilities between different organisations in the smart city context. This in turn may foster a new era of digital services that benefit the lives of citizens and organisations within the city.

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