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Smart cities, smarter values: Unpacking the ecosystem of urban innovation

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ABSTRACT

The beginning of this millennium has become the golden age of smart city initiatives, as local governments strive to exploit novel technologies to improve public services and the quality of life of their inhabitants. However, it is not enough to focus only on the technologies; we need to understand how value is identified, and how different parties approach that value on an ecosystem level. In this qualitative case study, two Finnish smart cities were examined by employing an ecosystem value balance framework to identify how the value proposition is created and what types of value can be captured during the early phases of the ecosystem. The results show that at the very beginning of the life cycle, monetary, epistemic, and social investments are required. The earliest values captured are epistemic, social, and functional. Prominent financial value is seen as a potential value, but to achieve it, the ecosystem should have a common purpose, successful external communication, low entry barriers, seamless internal information sharing, and plenty of co-operation between the ecosystem actors.

1. Introduction

A 'smart' city is an urban innovation ecosystem that is being introduced increasingly worldwide [1–3]. It can be argued that the first smart city initiative was launched in the 1970s, when Los Angeles created the first urban big data project (GlobalData Thematic Research, 2020; Kendig, 1976). Still, the beginning of this millennium has been the golden age for initiating smart city plans aiming to increase the competitiveness of their subregion by improving the public services and living conditions of its citizens, while offering opportunities for new, innovative, co-created multi-actor value propositions for citizens, companies, and the third sector ([2]; Cohen et al., 2016; [4]).

However, little is known about how ecosystems emerge. Thomas & Ritala (2021) have demonstrated that ecosystems often emerge through collective action, where the participants interact with the external environment and each other. This process requires shared legitimacy to facilitate the emergence and to reduce the liability of the newness of the emerging ecosystem. It has also validated IoT as a technological enabler for smart city ecosystems that can offer simultaneous positive impacts on business value creation, the environment, and quality of life (Grimaldi and Fernandez, 2019; Wang and Zhou, 2022). For this to happen, society has to become more inclusive, collaborative, accessible, and transparent ([3]; Wang and Zhou, 2023) – which requires perceived legitimacy from the parties involved.

Thomas et al. [5] have also argued that, to become established, an ecosystem should realize four criteria: value discovery, collective governance, platform resourcing, and contextual embedding. When it comes to smart cities, we can consider that contextual embedding comes from the City's other roles and the societal context. Platform resourcing is crucial and relies on the role of the City and public funding. For example, the EU aims to have 100 climate neutral smart cities by the year 2030 [6]. For this to become a reality, it allocated 360 million euros of funding for smart city projects during the financing period 2021–2023. Additionally, investments are made by the cities themselves and the participating companies. The third and fourth criteria, value discovery and collective governance, are perceived as case-specific and context-dependent [5].

Value discovery refers to establishing a joint value proposition for the ecosystem, where the value is seen as a function of benefits minus the commitment required (Lindič and da Silva, 2011). It does not refer to the value system possessed by the actors in the ecosystem. Consequently, this study focuses on the versatile dimensions of value propositions, rather than the internal value systems such as cultural, political, or moral views and norms.

This study also focuses on the early stage of smart city ecosystem emergence to investigate how to design the discovery of value, and how different parties approach that value. We employed the Ecosystem Value Balance (EVB) framework [7] to describe the ecosystem-level value

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distribution in two IoT-enabled Finnish smart cities. We demonstrate how the EVB framework can be used as a tool for strategic planning in ecosystems. Additionally, based on these two comparative cases, we demonstrate how differently perceived value potential can support the initiation of the ecosystem expansion, how diverse the value can be, and what kinds of activities can be required to achieve the potential. Furthermore, we propose that the perceived importance of different value dimensions evolves as the ecosystem progresses.

2. Previous studies on ecosystems, smart cities, and value

2.1. Ecosystems

The innovation ecosystem concept was introduced by Adner [8] when he described it as "a collaborative arrangement of firms combining their offerings to respond to customer needs". One of the latest definitions considers the innovation ecosystem to be an "evolving set of actors, activities, and artifacts, and the institutions and relations, including complementary and substitute relations, that are important for the innovative performance of an actor or a population of actors" [9]. Valkokari [10] emphasized that the innovation ecosystem is a geographically clustered set of actors having a shared intention to produce new innovations through exploring knowledge and exploiting the strengths of the ecosystem. Exploring knowledge requires a structure which enables the actors to see future opportunities and create innovative solutions, while exploiting includes coopetitive activities in offering the innovated solutions to customers. Hence, exploration and exploitation require different alignment activities and strategies [11]. This is likely to cause challenges in the successful co-ordination of the ecosystem, especially as the actors in an ecosystem are not governed hierarchically [12].

Moore [13] divided the life cycle of ecosystems into four phases: birth, expansion, leadership, and self-renewal. To create a viable and healthy ecosystem, the birth phase should be successful, i.e., a superior value proposition should be designed and connected to capabilities to deliver value [14]. Ecosystems can either emerge spontaneously or be purposely built. Whichever way the ecosystem is constituted, the members should have a common purpose (i.e., joint value proposition) and align their activities accordingly, which requires orchestration [15]. Furthermore, the ecosystem should ensure that it is accepted by the surrounding societal and competitive environment, instead of being seen as a destructive disruptor even in the early stages of its emergence [5].

2.2. Smart cities

Camboim, Zavislak, and Pufal [3] define a smart city as "an urban innovation ecosystem where knowledge easily flows from a deliberated interaction and collaboration among different stakeholders". In these ecosystems, citizens, companies, government, educational institutions, and the third sector collaborate to co-create innovations and share value, to improve the quality of life of the citizens, and to create new business opportunities for the companies [2,16,17]. The concept has been developed to illustrate a new urban environment that aims to create wealth and wellbeing while providing a prosperous environment for creativity and innovation (Camboim et al. , 2019).

While the traditional industrial city structures, together with the prevailing trend of urbanization, result in several issues such as overcrowding, unemployment, pollution, and traffic jams, the smart city approach focuses on hosting its citizens and providing a high quality of life [3,17,18] In a holistic approach to smart cities (e.g., Ref. [19]), a smart city has several dimensions: governance, environmental-urban, techno-economic, and socio-institutional, with each of those dimensions having their own driving elements (Appio, 2019 [3]; Wirzt & Müller, 2022). Any city aiming to become smarter will have to follow a comprehensive strategic plan to integrate the driving elements among these dimensions. Consequently, the process of urban transformation is led by the governance dimension [3].

Cities are complex co-evolutionary systems, where various stakeholders with distinct needs, expectations, cultural and social characteristics, competencies and values, live and operate together [20]. As with any other innovation ecosystem, a smart city should adapt to the changing expectations of citizens and the increasing number of actors and changing technologies, which requires the dynamic capabilities of sensing, seizing, and reconfiguring both the value proposition and ecosystem structure [4]. While, at the beginning, finding opportunities and developing the value proposition is essential, the ecosystem should also be able to adapt the value creation processes when the external environment changes. The same applies to the ecosystem actors. For a smart city to be ready for the expansion phase, it should have a clear leader, pre-set goals and communication principles, and trust between the actors [21]. Moreover, it is important to understand that the actors may have diverse, or even contradictory, expectations of the ecosystem.

Smart cities are often supported by an IoT platform to enable data collection, storage, and analysis [1]. Developing the digital platform requires substantial monetary resources and skilled employees. It also requires collaborative orchestrating skills to identify and engage other actors to join the ecosystem [5]. Dedehayir and Seppänen [22] have posited that the birth phase of an innovation ecosystem has two sub-phases – invention and start-up – both contributing to finding a joint value proposition. While the focus in the invention phase is more on discovering feasible technologies, in the start-up phase it is on developing the technology performance to be able to deliver the value proposition. Through these sub-phases the ecosystem converts its focus from invention to operationalization [22]. In the birth phase, the orchestrator role changes. During the invention sub-phase, the orchestrator is the platform technology developer, but during the start-up sub-phase, the key driver is the immediate customer (i.e., in this context the City) [22].

Gupta et al. [23] provide a detailed description of the complexity of orchestrating a smart city ecosystem. They identified three core themes of successful orchestration: (1) openness of technology and organization, (2) managing diffusion through shared learning and building trust and legitimacy, and (3) a shared vision through effective governance tools and coordinating structures. Implementing all of these simultaneously is challenging as it requires cultural changes, agility in project management, and a dual role for the orchestrator of manager and strategist, for example [23]. To be able to create a clear shared vision and a plausible strategy, the orchestrator, together with the key actors of the ecosystem, should have an understanding of the needs, resources, and uniqueness of the ecosystem, its actors, and value proposition [20].

2.3. Values

In an ecosystem, value is co-created by all of the ecosystem actors [24,25]. Compared with other collaborative constellations, the aim in an ecosystem is to share value with all of the actors, not just to maximize value capture for the lead organization [12,25]. The actors are interdependent, which enables more value for the customer than any of the actors could offer alone [8]. Dedehayir et al. [24] reviewed the roles of different ecosystem members in direct value creation, and listed the end user as the most important actor in value creation as the user is often the actor who defines the problem or need, which is then the triggering force for the ecosystem genesis [24]. As ecosystems are multilateral, the supplier-customer relations become bi- or even multi-directional, and understanding the customer perceived value becomes increasingly difficult.

In the current literature on business and management, value is predominantly seen as a financial or functional value. For instance, cost or profit are often considered the primary elements of value perceived by ecosystem actors (see, e.g., Ref. [26]). However, other types of value exist, too.

The five core value types identified in the previous literature are financial, functional, social, emotional, and epistemic [26–28]. Furthermore, value can be conditional, which means that the perceived value depends on the situation. For instance, typical conditional values are offered by seasonal products or services [28]. Table 1 explains the five value types (dimensions) with selected general examples. In addition, in the circular economy context, social value has been associated with social responsibility rather than with values related to social cohesion. Understanding the multifaceted nature of value is required in order to utilize the Ecosystem Value Balance (EVB) framework correctly.

Due to the co-creational characteristics of ecosystem value, all stakeholders must perceive the value to be obtained. This is a prerequisite for the ecosystem to succeed [30].

Polizzotto and Molella [30] proposed that ecosystems must employ the right type of actors in the right type of roles to ensure balanced value creation. Sorri et al. [7] have designed a framework for ecosystem value balance (see Fig. 1), which combines the five value dimensions of both perceived and potential value, as well as the commitments made to justify the right to participate in the ecosystem. While the prior literature on ecosystemic value is sparse, the value balance framework provides a tool for exploring value from the viewpoint of the whole ecosystem.

The EVB framework is based on the assumption of Social Exchange Theory [31], according to which each of the actors in the ecosystem is willing to join, and stay in, the ecosystem only if the perceived effort they employ for value creation is smaller than (or equal to) the sum of the value they capture and expect to capture in the future (i.e., the value potential) [7]. The aspect of including the value potential is novel and may explain why some actors join an ecosystem without seeming to capture value from it at the time of joining. This emphasizes the perseverance often required in implementing successful ecosystems. There are many examples of ecosystems where investors have spent enormous amounts of money for many years, trusting in the future success of the ecosystem (see, e.g., Ref. [32]) or where the third party actors have not seen the potential value clearly enough (see, e.g., Ref. [33]), leading to unrealized expectations of success. The EVB framework can be a tool for illustrating the strategic motivations that are typically difficult, yet important, to identify [7,20]

The EVB framework is a matrix (see Fig. 1), where all of the actors (such as the platform technology provider) or group of actors (such as consumers or citizens) are listed vertically. Horizontally, the framework includes three sections: commitment to value creation, captured value, and value potential. The commitment to value creation includes all kinds of efforts and investments the actor has made for the joint value proposition of the ecosystem in any value dimension. The captured value illustrates what kind of value, in any dimension, the actor can currently capture. The final section illustrates the value potential each actor expects to be able to capture in the future – once again in all of the different value dimensions [7]. The goal of an ecosystem level value proposition is to offer all actors enough value capture and potential for them to stay in the ecosystem.

In this study, the EVB framework is used to describe the value distribution in the case smart cities' IoT-enabled ecosystems, and to identify the critical steps in value creation to enable the ecosystem to develop to the next life cycle phase. The model has been complemented with the creation of an action plan. The EVB framework was selected as it offers a strategic understanding of the value expectations of ecosystem actors.

Table 1
Examples of key value dimensions [7,16,26–29].

Value Dimension	Value Examples
Emotional	Achievement, aesthetics, attention, badge value, cultural fit, fame, fun, loyalty, motivation, nostalgia, responsiveness, risk reduction, self-actualization, sensory appeal, stability, (mis)trust, wellness, empowerment, (dis)comfort
Epistemic	Collaborative, data, filtering, information, innovativeness, insight, interesting, knowledge, learning, novelty, transparency
Financial	Gaining investors, increasing brand value, making money, reducing cost
Functional	Accessibility, availability, convenience (reduce effort, avoid hassle), customization, durability, flexibility, integration, meeting specifications, quality, scalability, security (e.g., data security), simplicity, time savings, usability
Social	Engagement, group identification, interaction, network expansion, reference, reputation, sense of belonging, social responsibility, status

3. Methods and cases

3.1. Research setting and analysis process

The cases were selected purposely through intensity sampling [34] using three criteria. The primary selection criterion was that the projects had received EU Horizon funding for climate-neutral and smart cities and that the city organization had played a leading role in the project. Second, an ecosystem had been initiated together with industry, service providers, and non-governmental organizations. The third requirement was that the cities shared the same national culture to minimize the effects of cultural values. Furthermore, there are at least two general approaches to implementing vast projects such as creating a smart city: either to start from small projects and combine them to create a (hopefully solid) compilation of services, or to create a comprehensive vision and split that up into manageable projects. Therefore, as a last requirement, the cases were selected to represent these two approaches.

The two selected cases, Tampere and Turku in Finland, fulfilled these requirements. One of the cities (Tampere) had started a comprehensive project focusing on identifying as many IoT-enabled cases as possible and creating a project portfolio of those cases. The other case (Turku) had begun its smart city project by focusing on smart traffic solutions and leaving the other possibilities for the future. These cases were also optimal because both of them have experienced difficulties in expanding the ecosystem, i.e., moving to the next phase of the ecosystem life cycle – the expansion phase.

Focus groups were selected as a data collection method since the purpose of this study was to collectively produce and generate a joint understanding of the selected subject [35], i.e., a value proposition and expectations in the case of smart city IoT-enabled ecosystems. While the concept of value is not necessarily univocal, discussions enabled the participants to share their view verbosely. Hence, a focus group workshop was seen as the best option to gain reliable data where concepts were understood in a diverse manner. Open discussions where participants were encouraged to try to understand the other participants' views and actions were facilitated. These discussions were seen as a way to improve the authenticity of the study. Interviews would have lacked the possibility to build on another participant's ideas.

Substantial effort was put into creating and managing the focus groups. For one thing, representatives of the ecosystem orchestrator city organization were included in the planning phase of the data collection. Their role was important in selecting the participants as they knew all of the actor organizations. The participants were selected to represent a similar level (mid-management) of different organizations to minimize the power imbalance in the group. Second, each group and sub-group discussion was moderated by a researcher to offer all participants an equal opportunity to participate in the discussion. Also, the moderator ensured that the tone of the discussion remained respectful. The focus groups were organized virtually through MS Teams in October 2021. All of the discussions were video recorded. The meetings took approximately 4 h and had ten to fourteen participants plus three moderators. The first 15 min were used to introduce the subject. After that, the group was divided into three sub-groups of three to five participants with a neutral moderator to facilitate the discussion. The sub-groups discussed the topic for 15–20 min, followed by sharing the main points of their

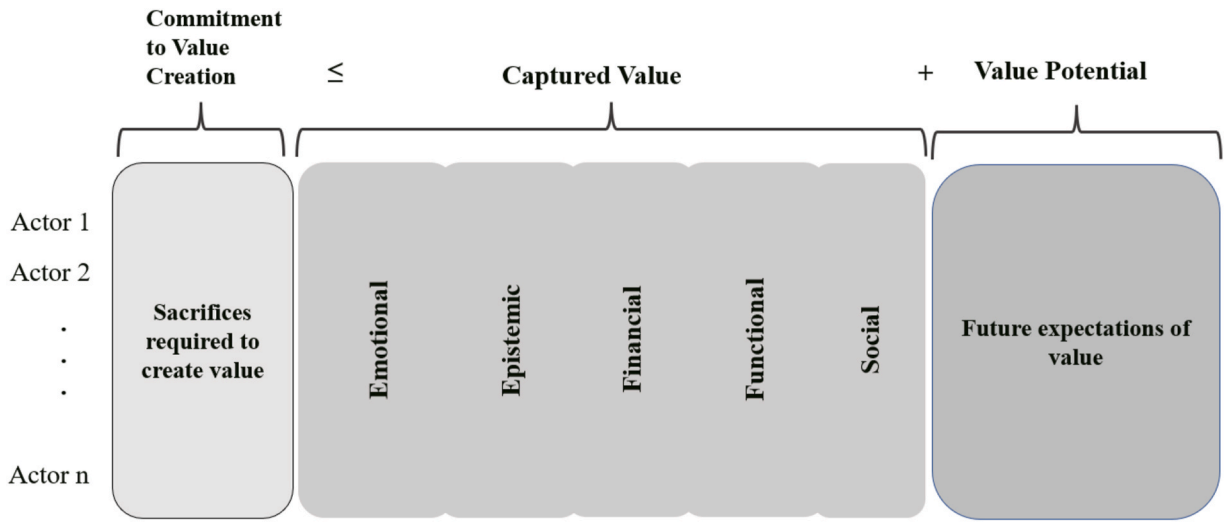

Fig. 1. Ecosystem value balance (EVB) model (modified from Ref. [7]).

discussion with the other sub-groups. This was repeated four times, once per section of the value balance. Each discussion dealt with only one question (see Table 2). This led to approximately 5 h of recorded discussions per focus group. All of the ideas were also documented on a shared Flinga whiteboard.

The videos and Flinga boards were coded and analyzed by two researchers using the qualitative data analysis software Atlas.ti. To maximize the accuracy and depth of the reporting, the material was not transcribed [36]. This enabled the researchers to return to the actual focus group situation to interpret the tone of the discussions for example, hence improving the authenticity of the analyzed situation. This was especially important since the concepts of IoT, value, and ecosystem were still ambiguous at that point. Using videos and coding directly for this also created an 'audit trail' to support the trustworthiness of the research and its reporting ([37], pp. 363–366).

A provisional coding [38] was created based on the literature of value dimensions [26,28], sections of the value balance (i.e., phases) [7], and actor types (e.g., City organization, service provider, IoT platform).

Additional codes were added in situations when the findings did not fit any of the original codes. For example, sustainability is not included in Sheth's dimensions, but it is often regarded as having social and economic value, for example in the circular economy literature (see e.g., Ref. [39]). The codes for required activities were created whenever a codable moment was identified. Furthermore, a code theme (Process) was created for collecting spontaneous feedback on the EVB framework or the workshop from the focus group members.

In total, 141 codes were identified in ten themes, leading to 949 quotations and 4556 records. Furthermore, a 15-page coding memo was created to increase the depth of the analysis. The quantified data section was then analyzed using code co-occurrence tables. The analysis was validated by three researchers.

Table 2
Questions per discussion.

Discussions	Question
Discussion 1	What kind of commitments has your organization taken on to create value for the ecosystem and its actors? Please consider all dimensions of value.
Discussion 2	What kind of value has your organization gained from the ecosystem? Please consider all dimensions of value.
Discussion 3	What kind of value does your organization expect to gain in the future? Please consider all dimensions of value.
Discussion 4	What actions should be taken in the ecosystem for the value potential to be achieved?

For reliability reasons, the data analysis results were also shared with the City representatives and the platform companies to discuss the findings, and to clarify any possible misunderstandings.

3.2. Description of the cases

The two cases selected were the Finnish cities of Tampere and Turku, which had received EU Horizon funding and had played a leading role in their respective projects. Both case cities (see Table 3) had been among the 100 cities selected to achieve the EU mission of carbon neutral and smart cities [40]. Furthermore, they had already been developing their smart city concepts for several years and were using the same IoT platform. Both had started strategical co-operation in creating digital solutions and becoming "smarter and better" within the EU-funded 6Aika project since 2014 ([41,42], n.d.).

The primary focus of Turku is to reach carbon neutrality by 2040. To reach this, Turku works towards becoming a smart city ("[43]," n.d.). The spearhead project of Turku, Civitas Eccentric, ended in 2021 [44]. It focused on implementing clean transport and urban freight solutions, which have significant potential to improve sustainability [45] The city administration, private companies, universities and civil society worked together towards the target. Though the project has ended, Turku is continuing its development towards becoming a true smart city as a part of Nordic Smart City network ("[46]," n.d.) and the CIVITAS community ("[47]).

Tampere aims to digitalize services and enable business opportunities through ecosystem approach ("[48]," n.d.). Tampere is one of three the Lighthouse cities of the EU Horizon STARDUST-project ("[49]," n.d.). These "lighthouses" create and test both technical and non-technical, interventional, smart solutions. The successful ones will then be copied to the rest of the Stardust cities. Compared to the CIVITAS cities, the STARDUST cities have more comrehensive target. They focus on green technical solutions and innovative business models

Table 3
Case description.

	tampere	turku
City population	245 000	195 000
regional population	394 000	330 000
scope of the project	Completely smart city	Sustainable and smart transportation
duration	5 years (ongoing)	8 years (ongoing)
EU Horizon Project	STARDUST (ongoing)	CIVITAS ECCENTRIC (ended 2021)

("[50]," n.d.).

Both cities have opened up their data extensively (including e.g., bus routes, underground plans, culture attraction locations, population and future estimations, noise measurements, and tap water quality measurements). Turku has 196 different data sources available, and Tampere has opened access to 109 different data sources.

Both cities have piloted multiple innovations. For instance, Turku has implemented a sharing economy solution, the 'Shareway' service for renting P2P parking spots. Another pilot allows a driver to book a parking place through an application, 15 min before arrival. In addition, two distinct types of secure and smart bike-parking concepts have been tested. In Tampere, the pilots have included real-time visibility and optimization of street maintenance (snow plowing, gritting, etc.), smart lighting, and smart urban security applications.

The differences between these two cases were the scope and composition in the focus group workshops. Due to the different "smartness goal" of the cities, it was considered appropriate to have a different scope in the workshop. Tampere took a comprehensive approach by analyzing the value proposition possibilities of the whole IoT-enabled smart city ecosystem, whereas Turku focused on a "service-level" ecosystem of sustainable and smart transportation. Regarding the focus groups, the Tampere group had members from the university, the business service development organization, other major cities, and the IoT platform provider, while Turku, on the other hand, had members from the local entrepreneur society and a complementary platform. Both groups included members from the City administration who had been participating in the smart city projects.

4. Findings from case analyses

Both cases were analyzed and complemented by cross-case analysis. The numbers in the tables refer to the number of times a certain code was used, i.e., when the subject was discussed in the focus group workshop. Therefore, the numbers should not be compared between cases; instead, the order of frequency and the proportions of prevalence are key.

4.1. Case: Tampere

The value balance framework of the ecosystem was created to establish a baseline for analysis (see Table 4). The table is structured so that the first column includes the actor types and the following six main columns include different value dimensions (sub-columns for how many times each dimension was mentioned as commitment, capture, or potential value). The square on the right includes sums of the value dimensions per actor type. This section goes briefly through the main findings from the three value balance perspectives: Commitment, Capture, and Potential.

4.1.1. Commitment

> "In general, in addition to novel technological solutions, the ecosystem has also developed processes, procedures, and communication. In other words, the development is comprehensive and done on multiple layers."

The service provider emphasized how they had invested in social value through interacting and co-operating with the other ecosystem actors, co-creating services and expanding their network. They had invested in data and information creation, technology development, and improving service availability.

The citizens were the pilot users of the first applications. They were required to download the respective application and to use the service, thus creating data for the City and the service providers.

The biggest role in driving the smart city ecosystem had clearly been taken by the City organization:

Table 4
Summary of value balance calculation for Tampere smart city ecosystem. (0 indicates no value, a dot(.)indicates no data).

City of Tampere	Emotional			Epistemic			Financial			Functional			Social			Sustainable			VALUE BALANCE *Sum of*		
	Co	Ca	P	Co	Ca	P	Co	Ca	P	Co	Ca	P	Co	Ca	P	Co	Ca	P	*Commitment*	*Capture*	*Potential*	*Net Value*
Business service develop	0	0	0	−2	0	0	−3	0	0	−2	0	0	−3	0	0	0	0	0	**−10**	**0**	**0**	**−10**
City	−4	19	25	−41	29	51	−60	9	31	−46	26	70	−47	25	45	−3	3	19	**−201**	**111**	**241**	**151**
Citizen	0	16	30	−1	7	24	−2	1	9	−2	15	44	−2	6	19	0	2	10	**−7**	**47**	**136**	**176**
Education and Research	−1	11	11	−15	26	29	−8	2	10	−21	11	17	−11	16	19	−3	0	1	**−59**	**66**	**87**	**94**
Entrepreneurial society	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	**.**	**.**	**.**	**.**
IoT Platform	0	6	11	−24	11	18	−29	7	23	−35	11	25	−23	16	37	−2	1	1	**−113**	**52**	**115**	**54**
Complementary platform	.			.			.			.			.			.			**.**	**4**	**4**	**8**
Service provider	0	9	21	−11	15	51	−13	5	39	−11	15	48	−16	16	47	−1	0	9	**−52**	**60**	**215**	**223**
Sum	−5	61	98	−94	89	174	−115	24	112	−117	81	207	−102	79	167	−9	6	40	**−442**	**340**	**798**	**696**

"Our role is to make sure the activities are aligned with the goals. We are the linking actor and bring stability to the ecosystem."

The IoT platform representative stated that they had invested in the smart city platform as they expected to be able to scale it up internationally. Their main contribution was in developing the IoT platform technology. Additionally, they had trained the users of other ecosystem actors. For them, the co-operation within the ecosystem had been important, hence, they had opened boundary resources and guaranteed data distribution through standardized methods.

4.1.2. Capture

"Sometimes acting according to your personal values or societal values gives not only pleasure but also a sense of having done 'the right thing'."

The only group of actors clearly able to benefit more than they had invested in the value creation seemed to be the citizens. However, there were no "pure citizens" present in the workshop as all participants estimated citizen thinking from their own viewpoint. Presumably, the participants are likely to use the smart city services more than the average user as they have taken part in their development. As the services were created to improve the user experience, make everyday life smoother, and reduce carbon emissions, it was estimated that the citizens had particularly captured functional value (e.g., service availability, convenience, and efficiency) and emotional value (e.g., meaningfulness, motivation, and excitement). One participant emphasized that emotional value could include more than just emotions. All the other value dimensions were also identified but less diversely and frequently. The least mentioned type of value was financial.

The service provider representatives described captured value more often and diversely than implemented value creation commitment. They had invested money and time. They identified multiple types of social, epistemic, and functional value that they had already been able to capture. For example, they found that the ecosystem shared information openly, they found the co-operation meaningful, and they were motivated to continue the co-operation. They had gained access to new data and knowledge, which improved their efficiency. They also found the network expansion valuable.

The education and research actors had been involved in developing the technologies and were pleased to capture data for their teaching and research activities. Additionally, they found the social network expansion valuable:

"A smart city ecosystem can highlight new research needs and assist in putting the research results into practice."

4.1.3. Potential

"It is important for the City that business actors are happy to operate in Tampere. The City [organization] can even enable new business opportunities for companies. This improves our reputation."

All of the actors felt that the ecosystem had more value potential than they had been able to capture so far. The City representatives considered the biggest potential to come from improved badge value and reputation, i.e., being a smart city indicates that the city is a forerunner, which improves the reputation of the city and, thus, its regional appeal and vitality.

The service providers regarded that the data and information offered a variety of potential. They emphasized especially the importance of the availability and quality of data, which could enable new business opportunities for them. So far, the financial value captured for the service provider had been minimal, but they expected to be able to create new scalable business and increase the brand value.

"There should be a utility company for data like there is for electricity and water supply. This could standardize the quality of data, which would lead to better data comparability on national, or even international, level."

For the citizens, the ecosystem can provide a large variety of value potential in all value dimensions. The highest potential was seen in improving citizen safety. For example, by analyzing the water consumption statistics, the authorities can identify senior citizens who may require support in living at home. The less they use water, the more likely they are not able to take care of their personal hygiene, for example, and thus would benefit from social services. Another example is more efficient and timely winter maintenance of sidewalks, which would reduce the risk of falling. Citizens would also benefit from improved air quality and other environmental improvements. For the other ecosystem members, the potential relies on the scaling of the existing value capture.

To summarize, financial and functional commitments were the most common, namely, investing time and money, creating technologies, ensuring service availability, and creating system integrations. Additionally, data collection, information processing, and value co-creation were seen as major commitments. From the current capture point of view, epistemic value (i.e., knowledge, data, information, and insight) was mentioned most often. Surprisingly, social value capture (co-operation, network expansion, and engagement) was mentioned nearly as often as functional value (service availability, efficiency, technology development, and usability). Functional, epistemic, and social values also have a key role in value potential. Environmental sustainability was seen to have value potential, especially for the City organization and citizens. Also, financial value (creating new business, increasing brand value, reducing costs, scalability, and regional vitality) increased in significance. It is worth noting that trust between actors was mentioned when discussing value potential but not before.

4.2. Case: Turku

This analysis began by creating the value balance that is illustrated in Table 5.

4.2.1. Commitment

"All actors should have a collective desire and objective to realize the ecosystem"

Also in this case, the majority of the commitment was made by the City organization. They had invested time in applying for external funding, managing projects, scanning partners, tendering. etc. They had also invested money in technology development. In addition to time and money, they had invested in data collection and processing to enable innovations and new knowledge to emerge. They motivated partners to join the ecosystem and promoted openness to generate the required cultural change. The change has required a new way of thinking and attitude from both the City organization and other ecosystem actors.

"The City has changed its role from service buyer to service enabler. This has required a new way of thinking internally but also plenty of communication to teach the suppliers and service providers to think differently. We are changing from sending out calls for bids to creating testbeds for service providers."

Had the IoT provider been present at the workshop, their role would also have been significant. However, their absence meant that their role in the overall picture was almost non-existent. Nevertheless, the role of the complementary platform became clear. The platform provider is a government organization, which focuses on the rail and road infrastructure between Finnish cities. Its aim is to have a key role in public transportation around and between cities, as well as in providing online data on road maintenance and road conditions, etc. They had invested

Table 5
Value balance of the Turku sustainable and smart transportation ecosystem. (0 indicates no value, a dot (.) indicates no data).

City of Turku	Emotional			Epistemic			Financial			Functional			Social			Sustainable			VALUE BALANCE *Sum of*			
	Co	Ca	P	Co	Ca	P	Co	Ca	P	Co	Ca	P	Co	Ca	P	Co	Ca	P	*Commitment*	*Capture*	*Potential*	*Net Value*
Business service develop	0	0	0	0	0	0	−1	0	0	0	0	0	0	0	0	0	0	0	**−1**	**0**	**0**	**−1**
City	−15	5	37	−53	16	39	−38	7	20	−16	8	15	−52	17	50	−3	2	7	**−177**	**55**	**168**	**46**
Citizen	−1	10	18	−2	12	13	2	2	6	0	27	42	−5	5	17	0	2	1	**−6**	**58**	**97**	**149**
Education and Research	0	0	2	0	1	4	0	1	1	0	0	1	0	1	1	0	0	0	**0**	**3**	**9**	**12**
Entrepreneurial society	−7	4	25	−31	10	26	−16	3	15	−10	1	9	−29	14	35	−2	0	2	**−95**	**32**	**112**	**49**
IoT Platform	0	0	18	0	2	18	0	0	6	0	2	7	0	2	28	0	0	0	**0**	**6**	**77**	**83**
Complementary platform	−13	9	27	−45	16	35	−29	11	20	−22	5	13	−42	18	33	−2	2	3	**−153**	**61**	**131**	**39**
Service provider	0	5	16	−3	10	16	−1	16	14	0	15	13	−3	12	33	−1	1	3	**−8**	**59**	**95**	**146**
Sum	−36	33	143	−134	67	151	−83	40	82	−48	58	100	−131	69	197	−8	7	16	**−440**	**274**	**689**	**523**

time and money in data collection, developing the technology of their own platform, and creating integration between platforms to enable new knowledge and insights to emerge. On the “soft side”, they had invested in co-creation and co-operation, engaging partners, and interacting within and between ecosystems. In this way, they had invested in ecological sustainability.

The third biggest actor in terms of commitment to value was the entrepreneur society of downtown Turku. They are an active ecosystem actor as they are facing the challenge of dwindling numbers of customers coming to the city center since the building of multiple large shopping malls outside the center in recent years. At the same time, driving and parking have become more difficult in the center. They had invested in the same values as the complementary platform, but to a slightly smaller extent and mainly through sharing their expectations and expertise.

In summary, the emphasis of value creation commitment had been on epistemic value (such as data collection and processing, information sharing and innovation of novel solutions), social value (i.e., co-creation, cooperation, interaction, and engagement), and financial value through investments of time and money.

4.2.2. *Captures*

”The ecosystem has brought us business but I see the economic values on society level to be even more significant”

At the time of the workshop, the service provider was able to identify more captured value than value creation commitment. The service provider company designs, builds, and administers a maintenance service network for the parking solutions. The company had been able to integrate the platform and had captured financial, functional, social, and epistemic value through relatively small and simple levels of commitment. The captured financial values had been both reduced costs and creation of new business. The captured functional values had been improved service availability and efficiency. The captured social values were for the most part related to engagement, network expansion, and co-operation.

The citizens have not been expected to invest much more than uploading some applications and accepting the terms and conditions to allow the other ecosystem actors to use the data they provide. In this way, it is estimated that they are capturing multiple types of value, such as more convenient, safe, and sustainable transportation chains, real-time information of a wider selection of services, time savings, and the gratification of being socially responsible.

The service providers are seen to have captured more value than they had invested. One reason for this could be that the service provider participating in the workshop had been able to implement their solutions in more than one pilot, thus they had already captured some financial value. Not all service providers have been able to do so yet. Hence, the balance is not likely to be equally good throughout the whole network of service providers.

Although, all the other actors are also already capturing some value, the balance is still negative for them, i.e., they had been and still were investing more in value creation than they can currently capture.

In general, value capture is measured in social, epistemic, and functional values. Social value is considered valuable in terms of co-operation, engagement, and being able to expand one’s co-operation network, while epistemic value is seen in an increasing amount of information and new knowledge. Finally, functional value can be captured through the innovative technologies developed, availability of services, and convenience.

4.2.3. *Potential*

”The vitality of the city and its sub-region will improve”

Regarding the potential value of the ecosystem, the main emphasis is

on social, epistemic, and emotional values. The biggest potential is seen in co-creation and co-operation. The epistemic value potential relies on increasing transparency, novel insights, and increased information and knowledge. The most important potential emotional values are trust, openness, and meaningfulness.

The most diverse potential is seen by the City representatives. They emphasize the social value potential. In addition to the 'co-concepts', they also believe that the reputation of the city might improve, which could lead to improved badge value and an increasing population. They also consider the improved transparency of processes and services to be important. The representatives hope the city will be able to gain some financial value by reducing management costs and offering services, while also finding new revenue streams.

The citizens gain multiple types of value based on improved services, both in terms of quantity and quality. The services improve the citizens' ability to plan trips conveniently and hence save time and costs, and they can feel engaged through value co-creation.

To summarize, the entrepreneur society and the complementary platform consider the social, epistemic, and emotional values the most significant for the same reasons as the others. All the actors in the ecosystem can achieve a positive value balance. However, when looking at the types of value, financial value is seen to be only slightly on the positive side. The same applies to sustainability. Both these factors can be seen as risks. A sustainability-oriented ecosystem may not survive unless it can offer significantly improved sustainability, especially if the financial value it offers is also relatively small.

4.3. Cross-case analysis

The analysis clearly shows that the majority of the work has been placed on the shoulders of the City organization and the platform provider. This is understandable as the ecosystems are nascent, hence they require significant effort from the orchestrators. Both balance sheets show that the balance is strongly dependent on the future potential. All of the actors, apart from the business service development organization, expect to capture more value from the ecosystem than they have committed. The business service development organization, Business Tampere, states on its website that it is a member of a dozen different ecosystems. However, the smart city is not mentioned on the list. They were invited to participate in the workshop by the City representatives of Tampere, which indicates that the City assumed Business Tampere was an ecosystem actor. This raises the question "do the actors know they are part of the ecosystem?", which was discussed several times in both workshops. Some considered that the value was available whether the actors realized they were in an ecosystem or not, while others saw a clear role as being the foundation of effective value creation and capture.

In both cases, the major commitments have been social, epistemic, and financial (see Table 6). The role of education and research organizations is clear in the Tampere ecosystem, especially in terms of epistemic and social value creation. Functional value was emphasized more in the Tampere workshop. This may partially have been caused by the dissimilar roles represented in the workshops. However, the views of both City representatives regarding their activity in developing functionalities were fundamentally different. The main difference was in the amount of participation in technology development. The City of Tampere is more active both in developing the platform and developing technologies together with the educational and research organizations.

Table 6
Order of discussion frequency of value potential dimensions.

Value Dimension	Tampere	Turku
Functional	1	4
Epistemic	2	2
Social	3	1
Financial	4	5
Emotional	5	3
Sustainability	6	6

Regarding value capture, the balance sheets are similar. The main values captured are epistemic, functional, and social. In Turku, the value seems to be fairly evenly balanced between the workshop participants. However, in Tampere, the City organization seems to have gained proportionally more value compared with the other actors. The difference in value capture when comparing the two cities is that Tampere describes capturing more emotional and functional value than Turku. The emotional value is mainly seen in the increased badge value and sense of meaningfulness for the employees. Efficiency is emphasized in the functional value captured by the City of Tampere. The most important captured values seen by the City representatives are network expansion and increased knowledge.

Although the platforms participating in the workshops were different (the main IoT platform and a complementary platform), value seems to be captured similarly. The complementary platform slightly lags behind in capturing functional value. This is understandable, as the main IoT platform mostly gains functional value in technology development as it has a key role in multiple pilots and the overall development of the smart city functionalities, whereas the complementary platform focuses only on traffic.

As illustrated in Table 5, the value potential, both "who" will capture value in the future and "what" type of value will be captured, is viewed differently between the cases. Consensus is found in respect to the sustainability value, which is the potential that was least discussed. The complementary platform representative and a City representative agreed that environmental sustainability has become a mandatory aspect during the past couple of years and, thus, is no longer an order-winning competitive factor.

The epistemic value is important, which was anticipated as smart city ecosystems rely strongly on data utilization. In the case of Tampere, all of the actors regard functional value as either the first or second most potential value. Also, every participant, except the IoT platform representatives, consider epistemic value to be among the two most frequently mentioned value dimensions. In the case of Turku, there is more variation. The epistemic value is regarded to be in the top two by every actor except the citizens. The social value dimension is considered to be in the two most important by everyone apart from citizens and education and research actors. The citizens are considered to gain the most potential value from the functional and emotional values (i.e., gratification of using efficient and effortless transportation).

It is significant that, although trust has been identified as the cornerstone of value co-creation and co-creation as essential for a platform ecosystem to thrive, trust was practically ignored in the value commitment and capture discussions. However, when analyzing the recordings, it can be noticed that the participants were relaxed and even shared business-critical information with each other, which is an implication of mutual trust. Maybe trust was not seen as an issue because the actors already trusted each other. Nevertheless, when the ecosystem expands, trust building may become a challenge.

As summarized in Table 7, 82 different values were found during the focus group workshops. While the different epistemic and financial values are rather obvious, the variety and number of different emotional, functional, and social values was bigger.

Most of the identified values are likely to be evaluated as positive but it is worth noting that some (such as fear of failing, risk of failing, or time) are clearly negative.

The value balance framework does not consider the activities required for achieving value potential. This was added to the workshop to give the ecosystem actors a possibility to create a realistic action plan. This phase was felt to be important by the actors and forty activities were identified.

Of these, one third were related to a common purpose and ecosystem governance (see Fig. 2). Other activities regarded as important were

Table 7
Summary of values identified during the workshops.

Value Dimension	Identified Value (in order of prevalence)
Emotional	Motivation, Badge value, Meaningfulness, Trust, Openness, Ecxitement, Safety, Achievement, Sense of belonging, Pleasure, Risk reduction, Pride, Comfort, Being ethical, Sense of fairness, Sensory appeal, Healthy, Courage, Fear of failing, Fun, Loyalty
Epistemic	Data, Information, Insight, Knowledge, Transparency, Novelty, Innovation, Feedback, Filtering, Predictability
Financial	Time, Investments, Making money, Reducing cost, Financial in general (not specified), Brand value, Shared resources, Vitality, Scalability, Gaining investors, Synergy, Risk of failing
Functional	Technology development, Availability, Efficiency, Convenience, Usability, Integration, Accessibility, Quality, Scalability, Time savings, Flexibility, Simplicity, Customization, Comparability, Security, Responsiveness, Serendipity, Standardized, Durability, Speed, Traceability
Social	Co-operation, Integration, Engagement, Cultural change, Reputation, Co-innovation, Social responsibility, Identification, Belonging, Reference, Health, Status, Environmental sustainability, Financial sustainability, Cultural and social sustainability

external communication (letting others know the ecosystem exists), reducing barriers to new actors joining, sharing information within the ecosystem, and increasing co-operation.

Surprisingly, extremely little attention was paid to data and its role. There was no discussion on standardizing the data interfaces, and creating quality requirements for the data only ranked 33 out of 40 (frequency 4). Keeping in mind that service quality is only as good as the quality of the data the service is based on, the ecosystem could benefit from more emphasis on data quality and agreement on the data interfaces.

There was no clear indication of who should take the governing and coordinating role. The City organization was seen slightly more often to be the leader of the ecosystem than the platform operator. The difference was clearer in the case of Turku but that could be because the "platform actor" was the complementary platform. The IoT platform company clearly stated that they are continuously searching for new actors for the smart city ecosystem to expand the value proposition.

5. Discussion

In the cases dealt with in this study, smart city development was mostly based on isolated pilot projects, leading to a fragmented structure and poor general awareness. The ecosystem actors may not even know that they are critical actors for the ecosystem to succeed. Better clarity regarding the actors' roles may increase the experienced value capture and future value potential. This became evident in several discussions on how to expand the ecosystem. "Marketing" the ecosystem was considered difficult when there was no clear common purpose.

During the birth phase of the ecosystem, the main commitments were the monetary and time investments in co-creating the required technologies and interacting within the expanding network. The epistemic and social value commitments were considered important. The birth phase offered some value capture for all actors. Network expansion and co-operation provided social value, which increased engagement and the motivation to participate in the ecosystem. Co-operation and new available data have led to an increase in knowledge and new insight, for example of how citizens' exercising habits are changing or how to improve predictivity in infrastructure maintenance. The third value dimension offered was functional value. The increase of novel technologies has led to the improved availability and usability of services, thus enhancing efficiency and convenience for citizens. The new pilots have included several new innovations; hence it can be concluded that the ecosystem has been in the innovation phase within the birth phase.

Increased trust was seen as offering potential in Turku. Similarly, in Turku, the value potential distribution was also slightly biased towards the City organization, complementary platform, and the entrepreneur society. It may be that lack of trust between the actors hinders service providers from seeing the value potential they could capture in the future.

Financial value comes in later stages of the ecosystem. This is understandable, as smart cities are more innovation ecosystems than business ecosystems. As smart cities rely partly on IoT, it can be argued that they may need to follow the same principle that Benitez et al. [51] identified in the Industry 4.0 context of shifting the mission from IoT solution co-creation to business solution co-creation during the expansion stage.

Sustainability did not receive the expected attention (see e.g. Ref. [52] to suggest how built environment's sustainability can benefit from new technologies). It may be that the sustainability aspects are

ACTIVITIES	FREQUENCY
Common purpose	175
External communication	68
Reduce barriers	63
Internal information sharing	59
Increase co-operation	57

ACTIVITIES	FREQUENCY
Creating a shared objective	42
Identifying actor-specific effects	21
Coordination	20
Identifying ecosystem-level effects	18
Ecosystem-level identity building	18
Aligning strategies	16
Describing the ecosystem	14
Creating a roadmap	9
Creating a data strategy	7
Identifying actors and roles	6
Identifying legislation and its effects on governance and control	4

Fig. 2. Most frequently identified required activities.

considered intrinsic de facto value propositions, and hence embedded in other dimensions (e.g., novel solutions or technology development). It is also possible that sustainability offers less concrete value than public debate leads us to believe.

The important activities for achieving future potential mainly focus on creating common targets, roles, and strategies to achieve the targets. This implies that the ecosystems are approaching the start-up phase in the birth phase. There is a clear aspiration among the current actors to expand the ecosystem and find new ways to co-create and capture value within the ecosystem.

The participants found the value balance framework helpful in creating an overall picture of the ecosystem, by offering a tool for verbalizing and communicating the value proposition to others. While actors may be able to estimate what kind of data it could be relevant to create, they do not necessarily understand what kinds of solutions can be provided with that data. The actors may have an idea about what kinds of solutions may be relevant to citizens for example, but they do not necessarily understand what data is required and how that can be collected to provide such a solution. A third challenge in understanding the value propositions is the temporal nature of value. One may value something in the present that will become invaluable in the future, therefore understanding the future expectations for the ecosystem is essential. It is important to realize, however, that expectations will change when the ecosystem evolves and the world outside the ecosystem transforms due to cultural or technological changes.

6. Conclusion

When the actors involved understand the mission of the ecosystem and align their strategic activities accordingly, it improves the chances of the ecosystem prospering. To achieve this, the actors should map the ecosystem-level value proposition and agree on how each of the actors supports value creation and delivery. Usually, it is not enough to focus on financial value, as the actors should have an incentive to stay in the ecosystem long before financial gains become available.

The complex nature of value poses a limitation to this study. The five value dimensions do not have a common reference point, which causes inaccuracies in assessing value. Even financial value is relative, as for a small company, grants can be a significant commitment or very valuable to capture, whereas the same amount of money is practically irrelevant to a large multinational company. Evaluating the value scale requires future research. A second limitation is related to the cases. This study includes only two cases, both from the same geographical and cultural area. In other areas, the results may differ. Therefore, replicating the study in other locations and cultures (e.g., Ref. [53]) could provide more insight to value creation and capture in smart cities. A third limitation is that in neither case were all members of the ecosystem present in the workshop. This may have resulted in some values and commitments being disregarded. Additionally, this study focuses only on the birth stage of an ecosystem, hence more research is required to better understand the later stages of ecosystem lifecycle and smart city determinants [54]. It would be especially interesting to elaborate whether the ecosystem value balance could be used in estimating the transition to the next life cycle phase. This would require the establishment of the above-mentioned measuring regime.

Both academics and practitioners would benefit from studying the question raised in the workshops: Does the actor need to know it is part of an ecosystem to be able to offer and capture value? Further studies are required to respond to this question.

CRediT authorship contribution statement

Krista Sorri: Writing – original draft, Visualization, Validation, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Katariina Yrjönkoski:** Writing – review & editing, Writing – original draft, Validation, Resources, Data curation. **Marko Seppänen:** Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision.

Declaration of competing Interest

None.

Data availability

Data will be made available on request.

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