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Smart city governance from an innovation management perspective: Theoretical framing, review of current practices, and future research agenda

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ABSTRACT

Smart city transitions are a fast-proliferating example of urban innovation processes, and generating the insight required to support their unfolding should be a key priority for innovation scholars. However, after decades of research, governance mechanisms remain among the most undertheorized and relatively overlooked dimensions of smart city transitions. To address this problem, we conduct a systematic literature review that connects the fragmented knowledge accumulated through the observation of smart city transition dynamics in 6 continents, 43 countries, and 146 cities and regions. Our empirical work is instrumental in achieving a threefold objective. First, we assemble an overarching governance framework that expands the theoretical foundations of smart city transitions from an innovation management perspective. Second, we elaborate on this framework by providing a thorough overview of documented governance practices. This overview highlights the strengths and weaknesses in the current approaches to the governance of smart city transitions, leading to evidence-based strategic recommendations. Third, we identify and address critical knowledge gaps in a future research agenda. In linking innovation theory and urban scholarship, this agenda suggests leveraging promising cross-disciplinary connections to support more intense research efforts probing the interaction patterns between institutional contexts, urban digital innovation, and urban innovation ecosystems.

1. Introduction

Innovation studies have struggled to keep "pace with the fast-changing economy and the world in which we live, in particular the […] growing need for sustainability" (Fagerberg et al., 2013, p. 11). Thus, innovation scholars have been encouraged to more vigorously engage with "disciplinary and inter-disciplinary fields that deal with issues of common interest" (p. 14), become aware of the role that innovation studies can play in overcoming sustainable development challenges emerging in other disciplines, and help determine how innovation "theories, frameworks, and research agendas may be adapted to fulfill this role" (p. 13).

Our study responds to this call for cross-disciplinarity by examining the governance of smart city transitions – a relevant subject matter of investigation in sustainable urban development research (Ooms et al., 2020) – in the framework of innovation management debates. Smart city transitions are long-term urban innovation processes that aim to leverage digital technologies to improve the socioeconomic and ecological conditions of urban settings (Mora et al., 2021). These innovation processes unfold gradually through a multitude of complementary short-to medium-term smart city projects (Bjørner, 2021). Typically based on cross-sector collaborations, these projects create the conditions necessary for new digital technologies and local practices to mutually adapt (Correani et al., 2020; Mat et al., 2016). They set in motion a dynamic learning environment where on-site experimentation with technological innovations, institutional reconfiguration processes, and other technological and non-technological changes are combined to support the progressive introduction of new digital technologies in urban sociotechnical systems and solve potential issues of technical and social adaptation (Carvalho, 2015; Meijer and Thaens, 2018; Raven et al., 2019).

Championed in many national and international urban policies, the

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innovation processes enacted by smart city transitions are considered to have a pivotal role in delivering more sustainable urban futures. This optimism demonstrates that "policymakers love […] smart technologies" (Kaika, 2017, p. 90) and explains why smart city transitions have been elevated into urban innovation actions of global strategic importance (The World Bank, 2016; United Nations, 2019, 2020).

Translating these expectations into urban sustainability enhancements poses critical challenges to public institutions (Michelucci et al., 2016), which are expected to lead the way (Gurick and Felger, 2022) without having access to a comprehensive knowledge base able to inform their decision-making. Managing smart city transitions as innovation processes requires referring to the dimensions that determine how such transitions take place (Crossan and Apaydin, 2010). Research addressing this subject has started growing only recently (Meijer and Bolívar, 2016) and has generated a rich and multidisciplinary forum alimented by literature siloed in different thematic areas. For example, risk management scholars have expounded on some of the most critical risks associated with smart city governance (Ismagilova et al., 2022; Ullah et al., 2021). Urban and regional studies have focused on examining technocratic approaches to smart city transitions and discussing their governance implications (Lim et al., 2022; Sheikh et al., 2023; Zhang et al., 2022). This research is grounded in a widely acknowledged objective to move beyond the inefficiencies of techno-centric smart city transitions (Mora et al., 2021). An objective also expressed in information systems literature on smart city governance (Rana et al., 2019; Verhulsdonck et al., 2023). Public administration and organization scholars have mostly focused on how to organize urban innovation ecosystems for sustaining smart city transition efforts (Pansera et al., 2022) and the role of local governments in the digital transformation process (Mukhtar-Landgren, 2021; Sancino and Hudson, 2020; Wirtz and Müller, 2022).

However, although the literature on the topic is expanding, no study has offered a comprehensive account of the governance dimensions that should be considered while dealing with these urban innovation processes (Fastenrath and Coenen, 2021). Overarching frameworks defining key governance mechanisms and how they should be managed are yet to be produced (de Hoop et al., 2021; Luque-Ayala and Marvin, 2015; Meijer and Bolívar, 2016; Mora et al., 2021). This knowledge gap limits scientific progress in the smart city domain and has important practical implications. Left with little guidance, many local governments have experimented with governance approaches that have proven incapable of sustaining improvements in urban sustainability (Hollands, 2015; Shelton et al., 2015). In documenting these shortcomings, the smart city literature has frequently reported on the adoption of approaches solely focused on the "technological and technical aspects of smartness" (Masik et al., 2021, p. 1) and affected by technocratic thinking (Jiang et al., 2022).

These facts trigger an important yet unanswered research question that we address in this study: how can innovation management theory help expand our understanding of smart city transitions and their governance dimensions? Acting "as a catalyst for change towards a sustainable development" (Van Mierlo et al., 2010, p. 320), smart city transitions are naturally connected to the field of innovation management but have received limited attention in this knowledge domain. Observing smart city governance from an innovation management perspective, by drawing upon innovation theory (Poole and Van de Ven, 2004), represents a valuable opportunity to unlock new practical insight and advance theorizing at the intersection between urban studies and innovation management, where a new line of enquiry focused on the urban dimension of innovation has been growing (e.g., Nilssen, 2019; Praharaj et al., 2018; Vallance et al., 2020).

Informed by this knowledge, we conduct a systematic examination of the available smart city literature, which is instrumental in achieving a threefold objective. First, we expand the theoretical framing of smart city transitions as innovation processes; we identify their governance dimensions and arrange them in an overarching governance framework that builds on fundamental aspects of innovation management literature. Smart city research has created a data-rich but fragmented knowledge landscape populated by many small-sample analyses, especially single case studies. Despite being valuable, these research efforts offer limited generalizability. Further, generating broader theoretical constructs on governance dimensions require taking stock of the evidence dispersed among disconnected analyses of smart city transition cases. Previously published review articles (e.g., Bastidas-Manzano et al., 2021; Ingwersen and Serrano-López, 2018; Kamran et al., 2020; Mora et al., 2017; Mora et al., 2019a; Mouazen and Hernández-Lara, 2021) do not address this challenge. Second, building on the results of our systematic analysis, we offer a thorough understanding of what is currently known about the governance dimensions of smart city transitions and what enquiries should be prioritized to overcome existing knowledge gaps. Third, we examine these gaps in the framework of innovation management theory, exposing the cross-disciplinary connections that can be forged between innovation studies and urban studies to improve our understanding of smart city governance.

The rest of this article is structured as follows. In linking urban studies and innovation literature, the next section introduces the multidisciplinary research space that smart city transitions have helped create. Moreover, it exposes the theoretical limitations that our systematic literature review addresses. The third section discusses the structure of the review process and methodological approach, while the fourth section focuses on the findings; it presents our governance framework for smart city transitions and offers a comprehensive overview of what we currently know about governance practices. The article concludes with a final section where existing knowledge gaps, together with the theoretical and practical contributions of our study, are captured and presented.

2. Smart city transitions and the urban dimension of innovation management

Over the last two decades, "the strongly firm-centric focus from the field's early years has given way to a broader perspective that places more emphasis on the environment in which firms operate, in particular the innovation systems in which they are embedded" (Fagerberg et al., 2013, p. 6). Innovation scholars have "put interactions, between different firms as well as between agents in the private and public sectors, at the very center of the analysis" (p. 7). This evolution has broadened the research agenda in innovation studies (Fagerberg et al., 2012). However, while expanding, this agenda has overlooked some of the most critical issues that affect the functioning of urban environments; one of the key "challenge for innovation studies scholars is to respond to the pressing world need for more equitable development [in urban settings], and to ensure we have the conceptual, methodological, and analytical tools needed to facilitate [the] shift toward innovation for sustainable [urban] development" (Martin, 2013, p. 174).

Urban environments are complex agglomerations of sociotechnical systems (Batty, 2005), whose interoperation generates a wide range of urban services (Ernstson et al., 2010). Although variations take place in local and regional growth capabilities (Acs and Armington, 2004), with an overall contribution to the global GDP of approximately 60% (Cadena et al., 2012), urban environments are generally considered as drivers of entrepreneurial opportunities (Florida et al., 2017; Tavassoli et al., 2021) and "sites of innovations" (Shearmur, 2012, p. S10). Therefore, urban innovation management has become a topic that needs greater attention. The urgency to understand how sustainability transitions and system innovation combine with urban settings has opened a new stream of research in which urban studies are coupled with innovation theory (Bulkeley et al., 2016; Frantzeskaki et al., 2017; Hansen and Coenen, 2015).

Studies on smart city transitions, which are positioned in this cross-disciplinary area of research, have exposed the inherent relationship between the smart city concept and system innovation (Leydesdorff and

Deakin, 2011). During smart city transitions, the sociotechnical systems of urban environments are subject to multidimensional changes, which allow new digital technologies with potential for sustainability enhancement to be integrated and deployed in urban settings (Barba-Sánchez et al., 2019). Existing configurations are replaced with new sociotechnical arrangements and, as a result of this reassembling process, the newly introduced technologies enhance the ability of urban services to meet societal needs sustainably (Mora et al., 2021). For this objective to be achieved, a sociotechnical transition pathway is necessary, which must create the conditions in which new technologies and existing local practices adapt mutually (Britton, 2019; Chang et al., 2020a; Elsner et al., 2019).

We know little about the conditions and factors affecting smart city transitions as urban innovation processes, especially the governance dimensions that should be considered. These transitions are generated from innovative combinations of sociotechnical elements, and their assemblage depends on existing local configurations of "resources, capabilities, strategies, and requirements" (Baregheh et al., 2009, p. 1324). Therefore, different configurations of contextual factors create variances in framing conditions, making it difficult to imagine a one-size-fits-all course of action (Esposito et al., 2021). However, despite these differences, a common pattern seems to emerge; governance mechanisms for smart city transitions appear to develop within three broad dimensions: *institutional context for urban innovation*, *urban innovation ecosystem*, and *urban digital innovation*. These governance dimensions recur frequently in the literature, where they tend to be observed separately and from a macro-level perspective; thus, we lack insight into their make-up (for example, see Appio et al., 2019; Ben Letaifa, 2015; Ibrahim et al., 2018; Mora and Deakin, 2019; Nam and Pardo, 2011). As a result, it remains unclear what components contribute toward structuring each governance dimension and how they are correlated. To overcome this gap and expand the current theorizing, a different level of inquiry is essential, with empirical studies that unpack these macro-level dimensions and explore their configurations through a smaller and more detailed level of observation.

Urban digital innovation reflects the infrastructural focus of urban planning (Ferrer et al., 2018), notably the technological assets (ranging from conventional to more advanced digital technologies) that constitute the backbone of any smart city developments (Angelidou, 2014). This governance dimension rises from the notion that technological advancements can help reduce sustainability pressures in urban areas by providing the means for introducing new digital services and interconnecting the information systems of urban sociotechnical systems (Jawhar et al., 2018; Jin et al., 2014). From an innovation management perspective, this governance dimension relates to digital innovation practices and reflects the need to develop "more accurate explanations of innovation processes and outcomes in an increasingly [urbanized and] digital world" (Nambisan et al., 2017, p. 223).

While emphasizing the key role of urban digital innovation, studies have also largely acknowledged that technological development enables smart city transitions instead of being an end in itself (Ardito et al., 2019; Schiavone et al., 2020). The smartness of cities increases only when digital innovation becomes instrumental in generating more sustainable urban living conditions (Ahvenniemi et al., 2017; Mora et al., 2019b), and the resources and capabilities needed to achieve this objective are distributed among diverse organizations (Appio et al., 2019). Smart city transitions "involve significant ecosystem innovation activities as diverse actors collaborate to create novel value propositions so that the sustainability of cities is improved" (Linde et al., 2021, p. 3). Consequently, the perspective of *urban innovation ecosystem* applied to smart city transition dynamics (see also Oomens and Sadowski, 2019) functions as an additional macro-level governance dimension. Smart city transition dynamics are determined by the co-evolutionary forces of change that "complex multilevel, multi-agent interactions" (Ossenbrink et al., 2019, p. 1) generate. Configurations of actors and roles (Ardito et al., 2019; Söderström et al., 2021), collaboration models (Paskaleva and Cooper, 2021; Schaffers et al., 2011), leadership styles (Sancino and Hudson, 2020), levels of heterogeneity (Mora et al., 2019b), collaborative planning processes (Stratigea et al., 2015), and conflict management (Kim, 2015) are examples of topics that researchers have been examining to better understand the collaborative innovation that is required to induce smart city transitions (Snow et al., 2016; Viale Pereira et al., 2017).

Finally, research recommends accounting for the body of policies, regulations, and institutional arrangements that municipal governments and other public sector organizations introduce to support smart city transitions and "steer the urban society toward collectively defined goals" (Pierre, 2005, p. 448). Their action frames an *institutional context for urban innovation*. According to Meijer and Bolívar (2016), governance in the framework of smart city transitions should be examined "as a complex process of institutional change" (p. 392), which needs to activate a "socio-techno synergy" (p. 394) in the urban system. To generate this synergy, the smart city literature frequently alludes to the formulation of smart city strategies (Angelidou, 2017; Brorström et al., 2018; Mancebo, 2020), which builds on innovation policies (Edler and Fagerberg, 2017) and orients smart-city-related activities across sectors (Albino et al., 2015; Anand and Navío-Marco, 2018).

3. Methodology

To examine the governance dimensions of smart city transitions, which are interpreted as urban innovation processes, we conduct a multi-disciplinary systematic literature review. We look into business and management literature on smart city transition dynamics (for instance, see the review on innovation in family firms by Calabrò et al., 2019) and examine this evidence base from an innovation management perspective. More specifically, to explore the governance dimensions of smart city transitions at a micro-level of observation, we develop a systematic literature review (Tranfield et al., 2003) as a standalone and independent study that can help create the foundations for advancing the current theoretical and practical understating of a given research domain (Kraus et al., 2022). By systematically collecting and synthesizing findings and perspectives from a multitude of empirical studies, systematic literature reviews help provide thorough overviews of research fields that are characterized by disparate lines of inquiry and interdisciplinarity; hence, uncovering the state of knowledge on topics and critical areas in which more research is needed (Paul et al., 2021; Snyder, 2019; Webster and Watson, 2002).

To minimize bias when reviewing articles and reach reliable conclusions, the adoption of a transparent and reproducible step-by-step methodology is considered a gold standard for reviewing articles (Davis et al., 2014; Tranfield et al., 2003). Accordingly, we start our systematic literature review by designing a rigorous procedure for selecting and assessing the scientific contributions that we have collected. This methodology includes six phases (see Fig. 1).

3.1. Phase 1: search and initial sample selection

Following prior studies, the first phase of any literature review entails the selection of a set of keywords to be used in searching for academic publications concerned with the topic under investigation (see Keupp et al., 2012; Nielsen, 2010). During the search for articles on the governance of smart city transitions, we only select "smart city" and "smart cities", without considering governance-related keywords. This decision is based on two motivations. First, the keyword "governance" may be implicit in an article, but may not appear in any of its sections. Second, governance-related keywords are disparate, so the likelihood to miss relevant terms and expressions is high. We believe this rationale made it possible to broaden the range of articles, avoiding the risk of incurring false-negative results or missing potentially relevant sources of information. For each article, the selected keywords should appear in titles, abstracts, or keyword lists. We perform the search in multiple

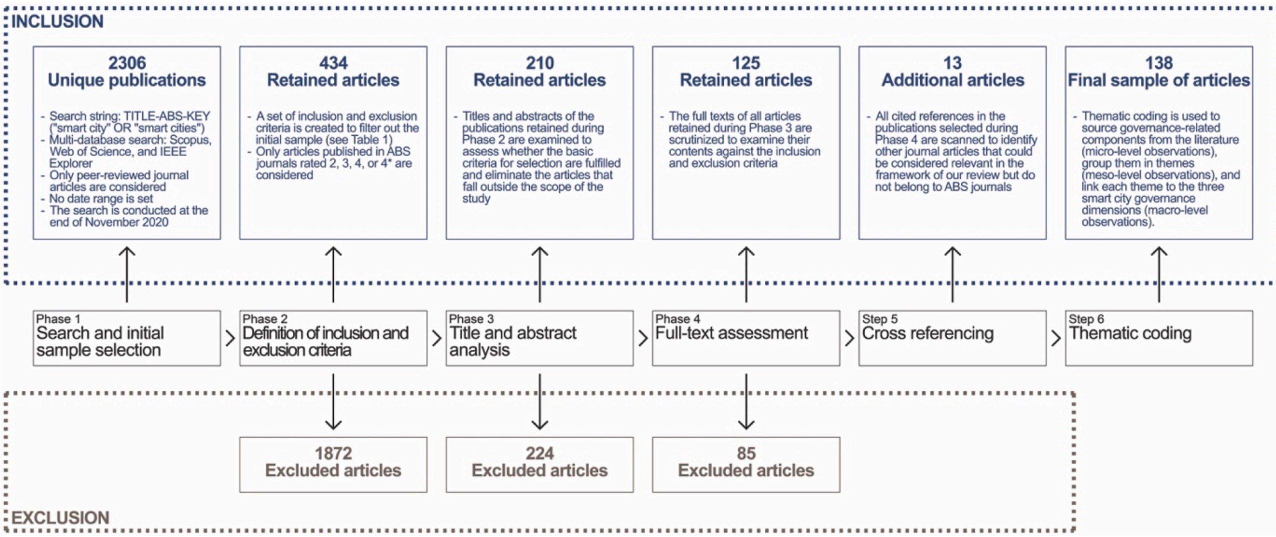

Fig. 1. Overview of the review process.

databases: Scopus, Web of Science, and IEEE Explorer. Only peer-reviewed journal articles are considered; therefore, books, book chapters, conference proceedings, and other non-refereed publications are excluded (Meier, 2011). No specific time limits are selected. We have considered all potentially relevant articles available online when the search was processed at the end of November 2020. After merging the results sourced from the different databases and after eliminating duplicate entries, we end up with an initial sample of 2306 unique records.

3.2. *Phase 2: definition of inclusion and exclusion criteria*

Before analyzing titles and abstracts, we filter the initial sample to avoid examining articles that are irrelevant to our investigation. When performing this selection task, we use a set of predefined inclusion and exclusion criteria (see Table 1). More specifically, data quality is ensured by considering the ranking proposed in the Academic Journal Guide (AJG) 2018 of the Chartered Association of Business Schools (ABS). We only consider articles published in ABS journals that are rated 2, 3, 4, or 4* (Beer and Micheli, 2018; Cortes and Herrmann, 2021). To further raise quality standards, we acknowledge that a more restrictive approach could have been used – for example, by also excluding ABS journals rated 2. However, the decision not to set overly restrictive limitations is critical when the subject matter of the investigation is examined in literature streams that span across different disciplinary fields and contexts of applications, as in the case of smart city governance. In addition to ensuring the high-quality standard of the material subject to analysis, this selection approach also helps ensure fit for purpose; we aim to review materials studying governance mechanisms in the context of innovation and sociotechnical transformation processes. This subject of investigation is central across business and management fields, which also includes urban and regional studies (see AJG 2018, Subject Area on Regional Studies, Planning and Environment). Moreover, proper fit is also guaranteed by the exclusion criteria, which made it possible to eliminate articles reporting on studies without clear implications for the governance of smart city transitions. Examples of articles excluded for this reason include publications discussing major trends in urban transformations, in which smart city transitions are frequently mentioned but not examined; articles only listing smart city initiatives among the possible contexts where new digital technologies are applied; and articles purely focused on technological experimentations for smart city transitions, in which it is common to find contributions reporting on new algorithms for smart city applications. Overall,

Table 1
Inclusion and exclusion criteria.

CODE	CRITERIA		REASONS FOR INCLUSION OR EXCLUSION
	Type	Focus	
INC.1	Basic	Quantitative and qualitative empirical studies	Inclusion of articles that offer empirical evidence, which is the main focus of this review.
INC.2	Basic	Theoretical papers	Inclusion of articles that provide the basis for better comprehending the theoretical constructs underlying empirical evidence.
INC.3	Thematic	Perspective	Inclusion of articles that make it possible to understand smart city transitions as an urban innovation phenomenon.
INC.4	Thematic	Business and Management outcomes	Inclusion of articles that explores how the governance mechanisms of smart city transitions take place.
EXC.1	Basic	Publication type and quality	Exclusion of books, book chapters, conference proceedings, theses, review articles, and articles not written in English. Exclusion of articles published in non-ABS journals or ABS journals rated 1.
EXC.2	Basic	Language	Exclusion of literature that is not written in English
EXC.3	Thematic	Unit of analysis	Exclusion of articles whose focus is not on smart city transitions (e.g., focus on some specific actors).
EXC.4	Thematic	Perspective	Exclusion of articles that provide general discussions about smart city transitions but do not provide sufficient information in relation to the design, development, and management of their governance mechanisms (e.g., articles that discuss relevance, impacts, advantages, and disadvantages of smart city transitions but without exploring how they are governed).

to avoid differences in coding and abstraction, this decision-making process is managed collaboratively by the entire research team, which includes all co-authors of this review article (Snyder, 2019). As a result of the filtering process, 434 articles are admitted to the subsequent phase, which entails analyzing titles and abstracts.

3.3. Phase 3: title and abstract analysis

All authors read the titles and abstracts of each retained publication to assess whether the basic criteria for selection are fulfilled and eliminate those articles that fell outside our scope (Adams et al., 2006; Keupp et al., 2012). The selection process is collaborative, with ongoing discussions on articles that are deemed to not fully meet all criteria (Combs et al., 2010). After checking the titles and abstracts, a total of 210 articles are admitted to the next phase, which requires examining the full texts (Bakker, 2010) – an indispensable phase considering that the actual contribution to smart city governance is not completely clear from titles and abstracts.

3.4. Phase 4: full-text assessment

Using the same collaborative approach, all authors scrutinize the full texts of the 210 articles to examine their contents based on the inclusion and exclusion criteria. After this assessment, only 125 out of 210 articles are retained.

3.5. Phase 5: cross referencing

All cited references in the selected publications are scanned to identify other journal articles that could be considered relevant in the framework of our review (Micheli et al., 2019; Ravasi and Stigliani, 2012). This ensures that potentially relevant articles that do not belong to ABS journals but may have relevant implications in the study of smart city governance are included. All additional articles are expected to comply with the same inclusion and exclusion criteria considered during the previous phases. This additional search has led to the identification of 13 additional articles that belong to areas under urban studies, but they are in journals that are not considered as part of business and management fields (for example, articles published in Urban Geography, Journal of Urban Technology, and Urban Policy and Research, just to name a few). However, these articles contain relevant implications for business and innovation management discourses. Therefore, the final sample for the analysis is composed of 138 articles.

3.6. Phase 6: thematic coding

All authors analyze the 138 articles to determine what micro-level components contribute to assembling the three macro-level governance dimensions discussed in the previous section of the article. We search for patterns of meaning in the qualitative data by using thematic coding. This coding process allows us to source governance-related components from the data (micro-level observations), group them in themes (meso-level observations), and link each theme to the three governance dimensions (macro-level observations), creating an association between each article and one or more observations (Ravasi and Stigliani, 2012). Through the coding process, which made it possible to transform the data in emerging theory (Mees-Buss et al., 2022), we produce a governance framework for smart city transitions, provide a comprehensive account of what is currently known about governance practices, and identify relevant research gaps that require further consideration.

4. Findings

In this section, we offer a comprehensive overview of the findings of the review process (Table 2), which is built on a data-rich environment: the knowledge accumulated through the observation of smart city transition dynamics in 6 continents, 43 countries, and 146 cities and regions (Fig. 3). This knowledge has been instrumental in structuring a smart city governance framework (Fig. 2) and gathering data that expose what is currently known about governance practices in the smart city domain. We present these practices in the following subsections.

Table 2
Governance framework for smart city transitions: information sources by micro-level components.

GOVERNANCE FRAMEWORK	CODED SEGMENTS	ARTICLES
Components	No	Citations
C1.1.1 Administrative structure	88	Angelidou (2014); Anthopoulos (2017); Barns et al. (2017); Brorström et al. (2018); Camboim et al. (2019); Coletta et al. (2019); Fromhold-Eisebith and Eisebith (2019); Giest (2017); Grossi and Pianezzi (2017); Gupta et al. (2020); Huston et al. (2015); Karppi and Vakkuri (2020); Kong and Woods (2018); Lee and Lee (2014); Lee et al. (2014); Lee et al. (2013); Maccani et al. (2020); Mora et al. (2019b); Nesti and Graziano (2020); Nilssen (2019); Odendaal (2003); Pittaway and Montazemi (2020); Praharaj et al. (2018); Raven et al. (2019); Sandulli et al. (2017); Sarma and Sunny (2017); Snow et al. (2016); Taylor Buck and While (2017); Trencher (2019); Vanolo (2014); Varró and Bunders (2020); Viale Pereira et al. (2017)
C1.1.2 Culture	36	Aina (2017); Anthopoulos (2017); Blanck et al. (2019); Cohen and Amorós (2014); Cowley and Caprotti (2019); Fromhold-Eisebith and Eisebith (2019); Kong and Woods (2018); Kraus et al. (2015); Lee et al. (2014); Leitheiser and Follmann (2020); Leydesdorff and Deakin (2011); Maccani et al. (2020); Mora et al. (2019b); Nam and Pardo (2014); Nilssen (2019); Offenhuber and Schechtner (2018); Pittaway and Montazemi (2020); Sandulli et al. (2017); Sarma and Sunny (2017); Scuotto et al. (2016); Trivellato (2016); Varró and Bunders (2020); Velsberg et al. (2020)
C1.1.3 Internal capabilities	54	Aina (2017); Angelidou (2014); Araral (2020); Axelsson and Granath (2018); Barns (2016); Castelnovo et al. (2016); Coletta et al. (2019); Cowie et al. (2020); Firmino and Duarte (2016); Fromhold-Eisebith and Eisebith (2019); Giest (2017); Huston et al. (2015); Kong and Woods (2018); Kuk and Janssen (2011); Lam and Yang (2020); Leitheiser and Follmann (2020); Mora et al. (2019b); Nam and Pardo (2014); Neirotti et al. (2014); Odendaal (2003); Pittaway and Montazemi (2020); Praharaj et al. (2018); Sandulli et al. (2017); Sarma and Sunny (2017); Sikora-Fernandez (2018); Taylor Buck and While (2017); Trencher (2019); Van Winden & Van Den Buuse (2017); Vandercruysse et al. (2020); Varró and Bunders (2020); Velsberg et al. (2020); Wang et al. (2019)
C1.2.1 Public procurement of technological innovation	12	Araral (2020); Barns et al. (2017); Fromhold-Eisebith and Eisebith (2019); Lam and Yang (2020); Maccani et al. (2020); Parks (2019); Sandulli et al. (2017); Sarma and Sunny (2017); Taylor Buck and While (2017)
	47	Aina (2017); Angelidou (2017); Anthopoulos (2017); Batty (2013);

(continued on next page)

Table 2 (*continued*)

GOVERNANCE FRAMEWORK	CODED SEGMENTS	ARTICLES
Components	No	Citations
C1.2.2 Technical regulations and standards		Chong et al. (2018); Giest (2017); Heaton and Parlikad (2019); Iveson and Maalsen (2019); Kong and Woods (2018); Li and Liao (2018); Mora et al. (2019b); Nesti and Graziano (2020); Nielsen et al. (2019); Parks (2019); Sarma and Sunny (2017); Sharma et al. (2020); Shelton et al. (2015); Van Winden & Van Den Buuse (2017); Velsberg et al. (2020); Wang et al. (2019); Yan et al. (2020); Zhang et al. (2020a)
C1.2.3 Technological innovation policies	71	Angelidou (2014), 2017; Anthopoulos (2017); Borrás and Edler (2020); Chatterjee et al. (2018); Dameri et al. (2019); Engelbert et al. (2019); Fromhold-Eisebith and Eisebith (2019); Grossi and Pianezzi (2017); Gupta et al. (2020); Heaton and Parlikad (2019); Ho (2017); Kummitha and Crutzen (2019); Lee et al. (2014); Leitheiser and Follmann (2020); Leydesdorff and Deakin (2011); Macke et al. (2019); Mora et al. (2019b); Odendaal (2003); Praharaj et al. (2018); Sharma et al. (2020); Sikora-Fernandez (2018); Tan (1999); Taylor Buck and While (2017); Trencher (2019); Trivellato (2016); Van Winden & Van Den Buuse (2017); Varró and Bunders (2020); Wathne and Haarstad (2020)
C1.3.1 Implementation strategies	102	Afzalan et al. (2017); Angelidou (2014), 2017; Anthopoulos (2017); Ben Letaifa (2015); Brorström et al. (2018); Caragliu and Del Bo (2019); Carè et al. (2018); Castelnovo et al. (2016); Coletta et al. (2019); Cugurullo (2018); Fromhold-Eisebith and Eisebith (2019); Giest (2017); Heaton and Parlikad (2019); Ho (2017); Huston et al. (2015); Kuk and Janssen (2011); Lam and Yang (2020); Lee et al. (2014); Leitheiser and Follmann (2020); Maccani et al. (2020); Mora et al. (2019b); Mosannenzadeh et al. (2017); Nam and Pardo (2014); Neirotti et al. (2014); Nesti and Graziano (2020); Offenhuber and Schechtner (2018); Paskaleva and Cooper (2018); Pittaway and Montazemi (2020); Praharaj et al. (2018); Raven et al. (2019); Sarma and Sunny (2017); Sikora-Fernandez (2018); Snow et al. (2016); Trencher (2019); Trivellato (2016); Van Winden & Van Den Buuse (2017); Vanolo (2014); Varró and Bunders (2020); Wirtz et al. (2020); Yeh (2017)
C1.3.2 Strategic orientation	185	Afzalan et al. (2017); Aina (2017); Angelidou (2014), 2017; Anthopoulos (2017); Ben Letaifa (2015); Brorström et al. (2018); Camboim et al. (2019); Castelnovo et al. (2016); Coletta et al. (2019); Cowie et al. (2020); Cowley and Caprotti (2019); Cugurullo (2018); Dameri et al. (2019); Fromhold-Eisebith and Eisebith (2019); Grossi and Pianezzi (2017); Hatuka and Zur (2020); Ho (2017); Huston et al. (2015); Kong and Woods (2018); Kraus et al. (2015); Kumar et al. (2020); Lee et al. (2013); Leitheiser and Follmann (2020); Maccani et al. (2020); Mahizhnan (1999); Masik et al. (2021); Mora et al. (2019b); Mosannenzadeh et al. (2017); Neirotti et al. (2014); Nesti and Graziano (2020); Nielsen et al. (2019); Nilssen (2019); Odendaal (2003); Paroutis et al. (2014); Praharaj et al. (2018); Raven et al. (2019); Russo et al. (2016); Sarma and Sunny (2017); Sepasgozar et al. (2019); Shelton et al. (2015); Sikora-Fernandez (2018); Snow et al. (2016); Tan (1999); Taylor Buck and While (2017); Trencher (2019); Trivellato (2016); Van Winden & Van Den Buuse (2017); Vanolo (2014); Varró and Bunders (2020); Velsberg et al. (2020); Wang et al. (2019); Wathne and Haarstad (2020); Wiig (2015); Yeh (2017); Zhang et al. (2020a)
C2.1.1 Cross-sector partnerships	74	Aina (2017); Angelidou (2017); Anthopoulos (2017); Belanche-Gracia et al. (2015); Ben Letaifa (2015); Brock et al. (2019); Camboim et al. (2019); Castelnovo et al. (2016); Chong et al. (2018); Coletta et al. (2019); De Guimarães et al. (2020); Fromhold-Eisebith and Eisebith (2019); Grimaldi and Fernandez (2019); Grossi and Pianezzi (2017); Hatuka and Zur (2020); Johnson et al. (2020); Kumar et al. (2020); Lee et al. (2014); Leitheiser and Follmann (2020); Leydesdorff and Deakin (2011); Luque-Ayala and Marvin (2016); Maccani et al. (2020); March and Ribera-Fumaz, 2016; Masik et al. (2021); Mora et al. (2019b); Mosannenzadeh et al. (2017); Nam and Pardo (2014); Nilssen (2019); Raven et al. (2019); Russo et al. (2016); Sarma and Sunny (2017); Scuotto et al. (2016); Snow et al. (2016); Tironi and Valderrama (2018); Trencher (2019); Van Den Buuse and Kolk (2019); Van Waart et al. (2016); Vandercruysse et al. (2020); Vanolo (2014); Velsberg et al. (2020); Wolff et al. (2020); Yeh (2017); Yu et al. (2019)
C2.1.2 Intra-sector partnerships	44	Afzalan et al. (2017); Allen et al. (2020); Barns et al. (2017); Coletta et al. (2019); Fromhold-Eisebith and Eisebith (2019); Giest (2017); Grimaldi and Fernandez (2019); Heaton and Parlikad (2019); Herrschel (2013); Kumar et al. (2020); Kummitha and Crutzen (2019); Lee et al. (2014); Lee et al. (2013); Leitheiser and Follmann (2020); Nam and Pardo (2014); Neumann et al. (2019); Nielsen et al. (2019); Pittaway and Montazemi (2020); Praharaj et al. (2018); Tan

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Table 2 (*continued*)

GOVERNANCE FRAMEWORK Components	CODED SEGMENTS No	ARTICLES Citations
		(1999); Taylor Buck and While (2017); Varró and Bunders (2020); Viale Pereira et al. (2017)
C2.2.1 Collaborative tools and spaces	210	Afzalan et al. (2017); Aina (2017); Allen et al. (2020); Andreani et al. (2019); Angelidou (2014), 2017; Anthopoulos (2017); Ardito et al. (2019); Barns (2016); Blanck et al. (2019); Brock et al. (2019); Camboim et al. (2019); Carè et al. (2018); Castelnovo et al. (2016); Chambers and Evans (2020); Chatterjee et al. (2018); Chong et al. (2018); Cohen and Amorós (2014); Coletta et al. (2019); Cowley and Caprotti (2019); Crivello (2015); De Guimarães et al. (2020); Fromhold-Eisebith and Eisebith (2019); Giest (2017); Gupta et al. (2020); Hatuka and Zur (2020); Ho (2017); Huston et al. (2015); Karppi and Vakkuri (2020); Kong and Woods (2018); Kraus et al. (2015); Kumar et al. (2020); Kummitha and Crutzen (2019); Lee et al. (2014); Lee et al. (2013); Leitheiser and Follmann (2020); Li and Liao (2018); March and Ribera-Fumaz, 2016; Masik et al. (2021); Mora et al. (2019b); Nam and Pardo (2014); Nesti and Graziano (2020); Neumann et al. (2019); Nielsen et al. (2019); Nilssen (2019); Paskaleva and Cooper (2018); Pittaway and Montazemi (2020); Praharaj et al. (2018); Russo et al. (2016); Sandulli et al. (2017); Sarma and Sunny (2017); Shelton et al. (2015); Snow et al. (2016); Sokolov et al. (2019); Stratigea et al. (2015); Taylor Buck and While (2017); Timeus et al. (2020); Tironi and Valderrama (2018); Trencher (2019); Trivellato (2016); Van Winden and Carvalho (2019); Van Winden & Van Den Buuse (2017); Vanolo (2014); Varró and Bunders (2020); Velsberg et al. (2020); Viale Pereira et al. (2017); Wang et al. (2019); Wathne and Haarstad (2020); Wiig (2015); Wolff et al. (2020); Yeh (2017); Zuzul (2019)
C2.2.2 Consensus building	150	Aina (2017); Angelidou (2014), 2017; Anthopoulos (2017); Axelsson and Granath (2018); Barns (2016); Behrendt (2016); Belanche et al. (2016); Ben Letaifa (2015); Brorström et al. (2018); Camboim et al. (2019); Carè et al. (2018); Castelnovo et al. (2016); Chambers and Evans (2020); Chong et al. (2018); Cowie et al. (2020); Crivello (2015); Cugurullo (2018); Engelbert et al. (2019); Fromhold-Eisebith and Eisebith (2019); Gupta et al. (2020); Huston et al. (2015); Karppi and Vakkuri (2020); Kitchin et al. (2016); Kong and Woods (2018); Kraus et al. (2015); Kuk and Janssen (2011); Leitheiser and Follmann (2020); Lim et al. (2018); Maccani et al. (2020); March and Ribera-Fumaz, 2016; Masik et al. (2021); Mora et al. (2019b); Nam and Pardo (2014); Neirotti et al. (2014); Nesti and Graziano (2020); Neumann et al. (2019); Nicholds et al. (2017); Nielsen et al. (2019); Odendaal (2003); Offenhuber and Schechtner (2018); Pittaway and Montazemi (2020); Praharaj et al. (2018); Russo et al. (2016); Sandulli et al. (2017); Sarma and Sunny (2017); Sikora-Fernandez (2018); Snow et al. (2016); Tan (1999); Taylor Buck and While (2017); Trencher (2019); Trivellato (2016); Valdez et al. (2018); Van Den Buuse and Kolk (2019); Van Winden & Van Den Buuse (2017); Vanolo (2014); Varró and Bunders (2020); Viale Pereira et al. (2017); Wiig (2015); Ylipulli et al. (2014); Zuzul (2019)
C2.2.3 Cooperation agreements	41	Angelidou (2017); Anthopoulos (2017); Behrendt (2016); Ben Letaifa (2015); Chatterjee et al. (2018); Fromhold-Eisebith and Eisebith (2019); Kong and Woods (2018); Lam and Yang (2020); Lee et al. (2014); Leitheiser and Follmann (2020); Nam and Pardo (2014); Nesti and Graziano (2020); Nicholds et al. (2017); Nilssen (2019); Pittaway and Montazemi (2020); Raven et al. (2019); Sandulli et al. (2017); Sarma and Sunny (2017); Snow et al. (2016); Taylor Buck and While (2017); Trencher (2019); Van Winden & Van Den Buuse (2017); Vanolo (2014); Varró and Bunders (2020); Wang et al. (2019)
C3.1.1 Broadband networks	19	Anthopoulos (2017); Araral (2020); Ho (2017); Kraus et al. (2015); Kumar et al. (2020); Lee et al. (2014); Sarma and Sunny (2017); Stratigea et al. (2015); Wirtz et al. (2020); Ylipulli et al. (2014); Zhang et al. (2020b)
C3.1.2 Data platforms	55	Abella et al. (2017); Anthopoulos (2017); Barns (2016); Barns et al. (2017); Ford and Wolf (2020); Giest (2017); Karppi and Vakkuri (2020); Kitchin et al. (2016); Kumar et al. (2020); Lee et al. (2014); Lim et al. (2018); Mora et al. (2019b); Ruhlandt et al. (2020); Sarma and Sunny (2017); Shelton et al. (2015); Trencher (2019); Van Winden & Van Den Buuse (2017); Viale Pereira et al. (2017); Wiig (2015); Wirtz et al. (2020); Yeh (2017); Ylipulli et al. (2014); Zeng et al. (2020); Zhang et al. (2020b)
C3.1.3 Sensor networks	38	Chambers and Evans (2020); Kumar et al. (2020); Lee et al. (2014); Luque-Ayala and Marvin (2016); Nam and Pardo (2014); Sharma et al. (2020); Tironi and Valderrama (2018); Vandercruysse et al. (2020); Velsberg et al. (2020)
C3.2.1 Business model	82	Abbate et al. (2019); Aina (2017); Angelidou (2017); Bresciani et al. (2018); Brock et al. (2019); Coletta et al. (2019); Crivello (2015); Cugurullo (2018); Ford and Wolf (2020); Fromhold-Eisebith and

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Table 2 (*continued*)

GOVERNANCE FRAMEWORK	CODED SEGMENTS	ARTICLES
Components	No	Citations
		Eisebith (2019); Gagliardi et al. (2017); Giest (2017); Grossi and Pianezzi (2017); Gupta et al. (2020); Kraus et al. (2015); Kuk and Janssen (2011); Kumar et al. (2020); Lam and Yang (2020); Lee et al. (2014); Li et al. (2016); March and Ribera-Fumaz, 2016; Paroutis et al. (2014); Raven et al. (2019); Sandulli et al. (2017); Sarma and Sunny (2017); Trencher (2019); Van Den Buuse and Kolk (2019); Van Winden & Van Den Buuse (2017); Vandercruysse et al. (2020); Viale Pereira et al. (2017); Wirtz et al. (2020); Zhang et al. (2020b)
C3.2.2 Service development cycle	154	Allen et al. (2020); Angelidou (2014), 2017; Anthopoulos (2017); Araral (2020); Baudier et al. (2020); Belanche et al. (2016); Belanche-Gracia et al. (2015); Ben Letaifa (2015); Castelnovo et al. (2016); Chambers and Evans (2020); Chang et al. (2020b); Chong et al. (2018); Cugurullo (2018); Fromhold-Eisebith and Eisebith (2019); Gagliardi et al. (2017); Grimaldi and Fernandez (2019); Hatuka and Zur (2020); Herrschel (2013); Kong and Woods (2018); Kraus et al. (2015); Kuk and Janssen (2011); Kumar et al. (2020); Lee et al. (2014); Lee et al. (2013); Li and Liao (2018); Lim et al. (2018); McCann (2017); Mora et al. (2019b); Mosannenzadeh et al. (2017); Nam and Pardo (2014); Nielsen et al. (2019); Odendaal (2003); Paskaleva and Cooper (2018); Sepasgozar et al. (2019); Shelton et al. (2015); Tironi and Valderrama (2018); Valdez et al. (2018); Van Waart et al. (2016); Vandercruysse et al. (2020); Vanolo (2014); Viale Pereira et al. (2017); Wiig (2015); Wolff et al. (2020); Ylipulli et al. (2014); Yu et al. (2019); Zhang et al. (2020a)

4.1. Institutional context for urban innovation

This governance dimension groups three thematic areas: public sector setting, policies and regulations, and strategic agenda. Together, they define a set of formal and informal institutions framing the context in which smart city transitions are designed and implemented.

4.1.1. Public sector setting

The thematic area relates to the idiosyncrasies of the public sector. Their combination affects how the urban innovation ecosystems underpinning smart city transitions are shaped and how urban digital innovation is approached. These idiosyncrasies include the administrative structure of public sector organizations, their internal capabilities, and culture.

Evidence shows that the public sector's administrative structure influences the establishment and governance of innovation partnerships (Barns et al., 2017; Van Winden & Van Den Buuse, 2017). The existence of administrative silos in public organizations and an excessive fragmentation of powers and responsibilities across different government levels, for example, can hamper intra-sector partnerships among public entities collaborating on smart city initiatives (Karppi and Vakkuri, 2020). To mitigate this issue, public sector organizations have been recommended to establish a dedicated smart city unit – referred to as smart city accelerators, teams, working groups, and taskforces (for example, see Nesti and Graziano, 2020; Sandulli et al., 2017). Two dominant configurations have emerged in comparative studies. In some cases, smart city units have been arranged as new divisions within municipal governments (Lee et al., 2014; Mora et al., 2019b), whereas other urban settings have set up new public-private organizations that are autonomous and have independent legal identities (Grossi and Pianezzi, 2017; Vanolo, 2014). Regardless of their configuration, these units display a similar mandate, which includes facilitating the formation of intra- and cross-sector partnerships by overseeing implementation efforts (Praharaj et al., 2018) and reinforcing learning cultures in municipalities (Camboim et al., 2019; Nesti and Graziano, 2020). The capability of these units to function effectively has been hindered frequently by limited autonomy in decision-making and a lack of resources, particularly human and financial (Maccani et al., 2020; Varró and Bunders, 2020).

During the analysis, the internal capabilities of municipal governments have recurred as a major factor affecting smart city transitions. To develop and manage smart city partnerships, the smart city literature emphasizes that municipal governments need "sufficient knowledge, expertise and resources to engage in negotiations with smart city providers" (Taylor Buck and While, 2017, p. 506). The skillset available within public sector organizations determine the extent to which they can develop and implement digital infrastructures and digital services (Trencher, 2019; Wang et al., 2019). Urban digital innovation can also be affected by the technological and financial resources of municipal governments (Paroutis et al., 2014; Sarma and Sunny, 2017). The latter reflects the spending capacity of municipal governments, lately constrained by the contractionary fiscal policies implemented in response to the global financial crisis (Araral, 2020; Leitheiser and Follmann, 2020). The availability of financial resources influences the strategic agenda of smart city transitions, as "resource scarcity might make municipalities more susceptible to adopting a narrow, technology-oriented view" (Varró and Bunders, 2020, p. 215) and push them to "dampen socially inclusive aspiration" (Huston et al., 2015, p. 73).

The culture of municipal administrations contributes toward shaping the strategic agenda for smart city transitions and the development of innovation partnerships that sustain the digital transformation process. In stressing this point, smart city researchers have highlighted that nourishing sustainable smart city transitions require municipal governments to embrace an open innovation mindset, "emphasizing the need to co-create and co-produce with citizens" (Trivellato, 2016, p. 349) and to overcome internal resistance to experimentation and cross-sector collaboration (Lee et al., 2014; Velsberg et al., 2020). This cultural shift has implications on formation of partnerships because, for example, evidence suggests that large firms prefer to partner with municipalities that possess "richer technological [and collaborative] ecosystems" and a higher propensity to innovate (Sandulli et al., 2017, p. 610). The culture of municipal governments has proven to affect "their attitude to explore, seek, and potentially implement technologies that are not yet mature" (Maccani et al., 2020, p. 11), which in turn, can influence the development of urban digital infrastructure and services.

4.1.2. Policies and regulations

This thematic area comprises the policies and regulations (adopted at different administrative levels) that shape the regulatory framework in which urban innovation ecosystems and urban digital innovation develop. While discussing regulatory frameworks for smart city transitions, the literature highlights the significance of technological innovation policies, public procurement of technological innovation, and technical regulations. Technological innovation policies refer to local and national policies adopted to support the development of technological innovation, such as national plans for smart cites, national funding schemes to test and pilot digital technologies, and municipal

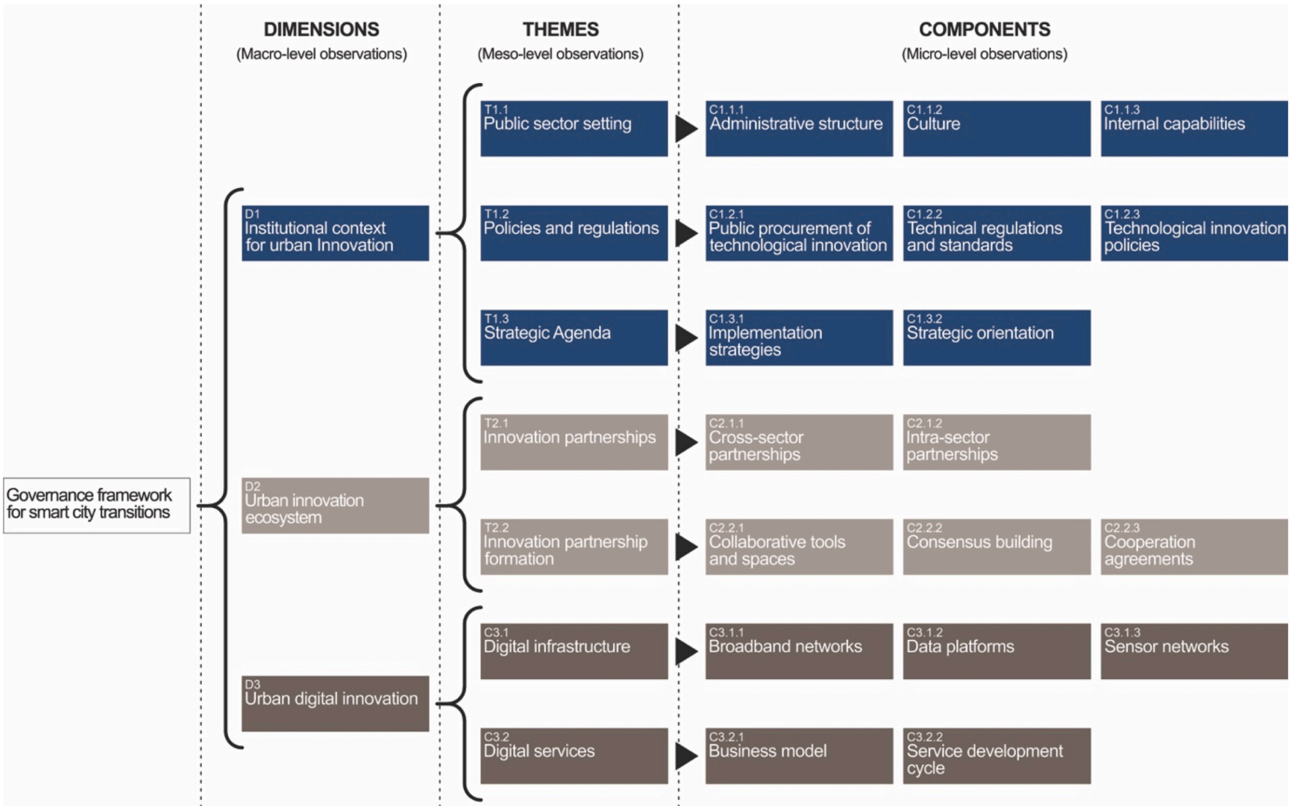

Fig. 2. Governance framework for smart city transitions.

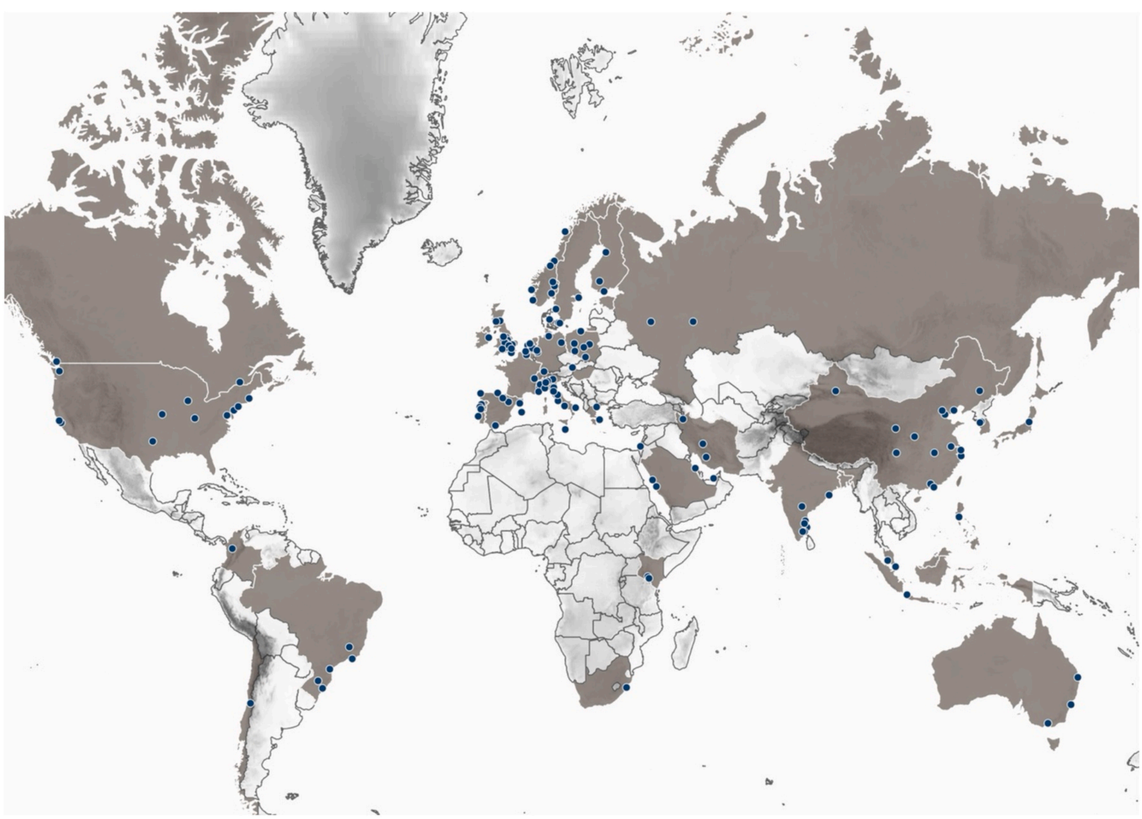

Fig. 3. Empirical settings examined during the review process. Interested urban areas and countries are marked in blue and brown, respectively.

policies on open data or digital inclusion (see Ho, 2017; Leitheiser and Follmann, 2020). Evidence from case study analyses suggests that national technological innovation policies can facilitate partnership formation by incentivizing knowledge-sharing among public partners (Van Winden & Van Den Buuse, 2017) and by helping municipal governments to develop the culture needed to successfully sustain their innovation partnerships (Kummitha and Crutzen, 2019). However, this ability to trigger collaborative efforts depends upon the core values underpinning the policy formulation process. For example, while examining national policies grounded in top-down and delocalized approaches to smart city initiatives, scientific enquiries have recorded negative effects, such as the diffusion of one-size-fits-all mentalities (Praharaj et al., 2018) and competition rather than collaboration among cities (Taylor Buck and While, 2017).

Technical regulations and standards, such as data protection laws and cybersecurity guidelines, are recognized as essential in orienting the development and scalability of digital infrastructure and services within urban settings. Their effectiveness is often undermined by a lack of harmonization and coordination among regulatory bodies, owing to "the ambiguous and overlapping distribution of responsibilities across many government agencies at various levels" (Li and Liao, 2018, p. 159). Local technological innovation policies play an important role in addressing this issue. Smart city research, for example, has reported on cases in which technological innovation policies contributes to filling this void by offering recommendations on how to manage open data and open-source technology (Iveson and Maalsen, 2019; Wang et al., 2019). However, these local policies have been frequently found to only consider a few urban policy domains, perpetuating a fragmented approach to the regulation of smart city projects (Trencher, 2019). Therefore, scholars have urged the adoption of holistic policy frameworks addressing multiple sociotechnical aspects of smart city transitions, including frequently overlooked implications of digital rights and the ethics of technology (Angelidou, 2014; Chatterjee et al., 2018).

Finally, legislation governing the public procurement of technological innovation is widely considered a critical factor influencing innovation partnerships and the strategic agendas that direct smart city developments (Fromhold-Eisebith and Eisebith, 2019; Sarma and Sunny, 2017). Several studies have found the complexity and duration of traditional procurement processes to be unfit for smart city projects; evidence suggests that traditional procurement processes can have a detrimental effect on the participation of external partners in smart city initiatives (Maccani et al., 2020) and restrain the technological solutions that municipal governments can select as part of their implementation strategies (Barns et al., 2017). Scholars have recommended introducing innovative approaches to public procurement, which are necessary to provide smart city initiatives with "the time and flexibility required for the experimentation and consolidation of new technologies or public services" (Sandulli et al., 2017, p. 615).

4.1.3. Strategic agenda

Developed at the municipal level, the strategic agenda includes the strategic orientation and implementation strategies that should guide and coordinate the actions of the municipal government and all other actors involved in developing smart city initiatives. The strategic orientation sets the objectives and applications domains that municipal governments and their stakeholders intend to prioritize. The evidence-based advice that scholars offer to the public sector is to formalize this orientation with a smart city plan or vision statement (see Anthopoulos, 2017; Tan, 1999); the adoption of official strategic documents can facilitate consensus building among project partners (Brorström et al., 2018) and safeguard the long-term stability of their cooperation agreements (Wang et al., 2019). Scholars have also emphasized the importance of adopting a dynamic rather than static perspective (Mora et al., 2019b). The strategic orientation has been described as a living document that should evolve over time to respond to contextual changes, such as the need for technological updates and maintenance operations or revisions of urban sustainability priorities (Ho, 2017; Lee et al., 2013). In Seoul, South Korea, and Rotterdam, Netherlands, for example, this adaptive approach has been found to bolster long-term collaborations and the exploitation of urban innovations beyond experimentation phases, thereby enhancing the sustainability and scalability of digital services (see Anthopoulos, 2017; Varró and Bunders, 2020).

Researchers suggest that the strategic orientation should be citizen-centric rather than technology-driven, to avoid "technological solutionism" (Ho, 2017, p. 3113) and ensure that smart technologies become the means to tackle socioeconomic and environmental problems (Praharaj et al., 2018) instead of solely pursuing commercial interests. The smart city literature recommends defining strategic orientations by adopting participatory and inclusive processes and tailoring them to local-context conditions by considering available resources and reflecting on the needs of different stakeholders (Angelidou, 2014; Kong and Woods, 2018; Paroutis et al., 2014). Technology-oriented and business-led strategies can easily prevail in urban innovation ecosystems that lack strong political leadership (Ben Letaifa, 2015; Brorström et al., 2018).

Strategic orientation should translate into implementation strategies that articulate how smart city transitions are expected to be operationalized (Castelnovo et al., 2016; Mosannenzadeh et al., 2017). These strategies should facilitate a detailed understanding of the funding sources that will be made available to support the transition process. The data collected during the review show that most smart city initiatives rely on both private and public funding (Angelidou, 2017; Anthopoulos, 2017). The contribution of private investors has emerged as essential for the sustainability of smart city transitions, especially in times of constrained public budgets (Mora et al., 2019b). However, an excessive reliance on private funding has also raised concerns as commercial investors may be reluctant to back socially oriented or experimental projects with limited profitability (Leitheiser and Follmann, 2020). Thus, the financial support of public institutions has been advocated to "foster initiatives in which local start-ups or middle-sized firms have the skills or capability to collaborate with government agencies" (Lee et al., 2014, p. 92).

Implementation strategies are also instrumental in clarifying the digital technologies that will be introduced in different sectors owing to the smart city transition process. It is generally acknowledged that the technology selection process should build on place-based considerations (Trencher, 2019) by taking into proper account existing technological resources and regulations, to avoid duplicate efforts and interoperability issues (Afzalan et al., 2017). Smart city research recommends heeding the importance of technological obsolescence and maintenance, which can generate hidden costs and unforeseen complexities, especially considering that budget constraints have been highlighted as a major challenge while selecting technological solutions (Fromhold-Eisebith and Eisebith, 2019; Offenhuber and Schechtner, 2018).

Implementation strategies, according to evidence, should also embrace a portfolio approach to smart city projects (Anthopoulos, 2017; Lee et al., 2014; Neirotti et al., 2014). This approach has been associated with several benefits: strengthening the capability of different actors to work together, enhancing the synergies among different digital services, accelerating the transfer of lessons learned from completed smart city initiatives to new collaborative projects, and supporting organizational ambidexterity (Raven et al., 2019; Van Winden & Van Den Buuse, 2017), by helping strike "an appropriate balance between diverse service exploration in different domains and intensive service exploitation" (Lee et al., 2014, p. 95). Case study analyses show that a successful portfolio approach is favored by the existence of open data infrastructure and the overseeing agency of a smart city unit (Coletta et al., 2019).

While defining implementation strategies for smart city transitions, scholars have also recommended setting up dedicated monitoring systems and performance evaluation measures (see Fromhold-Eisebith and Eisebith, 2019; Sikora-Fernandez, 2018; Yeh, 2017). These tools should enhance transparency and accountability while ensuring alignment between the objectives of smart city initiatives and their outcomes (Mosannenzadeh et al., 2017). The literature shows that producing overall assessments of smart city projects and transitions is challenging because of the lack of smart-city-related evaluation tools and methodologies. For example, the experience of Gothenburg with assessing smart city transition processes has revealed "the large number of unmeasurable aspects and a tendency to measure only what could easily be measured" (Brorström et al., 2018, p. 198).

4.2. Urban innovation ecosystem

This governance dimension groups the meso-level themes *Innovation Partnerships* and *Innovation Partnership Formation*. The former refers to the alliances formed by municipal governments with actors who are involved in smart city projects, whereas the latter encompasses the wide range of instruments and activities that can be used to structure and manage these partnerships.

4.2.1. Innovation partnerships

The literature distinguishes between two types of innovation-oriented coalitions that are established to sustain smart city transitions: cross- and intra-sector partnerships. The former includes actors from different sectors, such as coalitions between municipal governments and private suppliers, associations between public organizations and third-sector organizations, and collaborations connecting municipal authorities and local entrepreneurs to residents. Intra-sector partnerships include actors belonging to the same sector. In the smart city literature, this second type of innovation partnerships has received less attention than cross-sector collaborations. The few studies that looked at intra-sector partnerships are primarily focused on the collaboration between public organizations at different geographic and administrative levels, whereas little is known about the cooperation between private companies in the context of smart city transitions.

In cross-sector partnerships, the collaboration between public and private organizations has proven to be "the core engine behind [...] smart city development" (Mora et al., 2019b, p. 76) as the expertise and financial resources of private companies is essential to successfully implement digital infrastructure and digital services. However, smart city research has stressed that the cooperation between public and private entities is often undermined by the power relationships embedded in the urban innovation ecosystem. Besides being subject to political clientelism and pressures from influential urban actors (Varró and Bunders, 2020), cross-sector partnerships are affected by existing imbalances in the control of urban digital technologies (Taylor Buck and While, 2017), especially in smaller cities and peripheral regions that are less attractive to technology vendors because of their limited market potential (Cowie et al., 2020; Neirotti et al., 2014). Therefore, the implementation strategies underpinning smart city transitions may prioritize the economic goals of some partners over the achievement of public interests. For example, in some cases, evidence has shown that private suppliers may take advantage of their market power to impose one-size-fits-all technological solutions, which are more profitable but unlikely to address local development needs (Trencher, 2019).

To mitigate these collaborative challenges, scholars have recommended adopting a quadruple-helix approach to the development of urban innovation ecosystems, arguing for the need to connect public sector organizations and private companies to academic institutions and residents (Camboim et al., 2019; Mora et al., 2019b; Nilssen, 2019). The collaboration among these four groups of actors is considered a safeguard against one-size-fits-all mentalities. Evidence demonstrates that this multi-stakeholder structure can help urban innovation ecosystems improve the responsiveness of smart city projects to local development needs, because the active engagement of diverse actors is intended to provide complementary perspectives on urban problems (Ben Letaifa, 2015). Yet, empirical research has highlighted that municipal governments often struggle to effectively engage citizens and other actors in smart city transitions, where participation may be constrained by neoliberal logics, power struggles, and contextual factors, such as digital divides. Studies on European cities, for example, have noted that the willingness of citizens to cooperate with municipal governments largely depends on their sense of belonging to the city, which ultimately influences the legitimacy and acceptance of new digital solutions within the local community (Anthopoulos, 2017; Grossi and Pianezzi, 2017; Nesti and Graziano, 2020).

The smart city literature also stresses the importance of intra-sector partnerships, with a primary focus on public sector organizations. Their cooperation is expected to improve the allocation of resources, enhance the coordination of different smart city initiatives, and enable data- and knowledge-sharing in the service design cycle (Herrschel, 2013; Nam and Pardo, 2014; Pittaway and Montazemi, 2020). However, intra-sector partnerships are often undermined by the fragmented structure of the public sector and political tensions reflecting the "mismatch between national innovation policy and local political priorities" (Taylor Buck and While, 2017, p. 515). To overcome these challenges, scholars have suggested setting nationwide policies and benchmarking tools to help local authorities align their goals and actions in the context of smart city transitions (Nielsen et al., 2019; Praharaj et al., 2018). Moreover, smart city scholars have highlighted the importance of establishing smart city units to enhance coordination among different administrations involved in smart city projects (Coletta et al., 2019).

4.2.2. Innovation partnership formation

Given the challenges that both cross- and intra-sector partnerships face in the context of smart city transitions, research has examined a wide array of mechanisms that help sustain the development and management of these alliances. These mechanisms affect innovation partnership formation, which has emerged as a key thematic area that brings together observations on the cooperation agreements underpinning smart city partnerships and the collaborative tools and spaces used to promote consensus building within urban innovation ecosystems.

With respect to the cooperation agreements supporting the diverse alliances formed within the urban innovation ecosystem, various models have been proposed, such as public-private partnerships, special purpose vehicles, citizen-driven cooperatives, and partnerships with local utilities (Lee et al., 2014; Wang et al., 2019). Some studies have emphasized the "importance of formalizing collaboration arrangements" (Nam and Pardo, 2014, p. 57), whereas others have stressed the need to adopt flexible contracts with less bureaucratic control, providing the time and flexibility required for the experimentation and consolidation of new technologies" (Sandulli et al., 2017, p. 615). Although a systematic overview of the implications linked to different cooperation agreements is lacking, scholars agree on the importance of adopting dynamic collaborative arrangements that adapt and evolve through the lifecycle of smart city projects and transition processes (Van Winden & Van Den Buuse, 2017).

The literature has paid more attention to the role played by consensus building in partnership formation, which encompasses a wide range of tools and measures that actors can use to overcome collaborative tensions affecting innovation partnerships. Given that municipal governments and their partners may have diverging objectives and interests, smart city scholars recommend setting the strategic orientations of smart city transitions through an open and inclusive process that accounts for the priorities and expectations of all actors involved (Andreani et al., 2019; Fromhold-Eisebith and Eisebith, 2019; Trivellato, 2016). This inclusive approach has proven to be a possible remedy for the conceptual ambiguity that has often been observed in cities lacking a collective understanding of how smart city transitions should be conceived (Zuzul, 2019). Without a productive and open debate on the meaning of smartness, the smart city concept risks being perceived as an "empty slogan" (Crivello, 2015, p. 919). Consequently, a clear definition that is shared and agreed upon by all local stakeholders is needed.

In relation to consensus building processes, the literature also remarks the relevance of local or supralocal knowledge sharing networks. Case studies have emphasized the contributions of academic institutions in developing "an integrated knowledge base specific to the local government context" (Pittaway and Montazemi, 2020, p. 10), alongside city-to-city knowledge exchange mechanisms that allow cities "to share their experience in one sector with other city governments and possibly gain insight into best practices" (Giest, 2017, p. 952).

To generate consensus within their partnerships, municipal governments are encouraged to build relationships of trust with other involved parties. This can be achieved by replacing bureaucratic control with mechanisms of horizontal coordination, like smart city units. In Trento, Italy, for example, a shared management approach, combined with a joint public–private smart city unit, is found to effectively generate trust and stronger collaboration linkages between the municipal government and its partners (Sandulli et al., 2017, p. 615).

Studies have also shown that reaching a consensus requires the political support of local administrators, which has been typically articulated in a long-term vision for smart city transitions and in opportunities for co-creation (Mora et al., 2019b; Nesti and Graziano, 2020). To perpetuate political commitment throughout the lifecycle of smart city projects, positioning smart city units close to leading actors in local governments has been recommended as it is expected to facilitate "the collaboration with the innovation partner(s) and ensure that the focus remains on creating public value" (Neumann et al., 2019, p. 11). Political change has been found to affect the long-term stability of smart city transitions owing to "the temporary nature of local authorities and the lack of willingness to continue past directions of development after local elections" (Sikora-Fernandez, 2018, p. 58).

Additionally, smart city research has uncovered the importance of leadership in stimulating stakeholder buy-in and coordinate key platforms (Taylor Buck and While, 2017) in urban innovation ecosystems. Given the complexity and heterogeneity of the innovation partnerships underpinning smart city transitions, researchers have agreed that municipal governments should maintain a leadership role (Praharaj et al., 2018; Viale Pereira et al., 2017). However, attention is drawn to the importance of not interpreting strong municipal leadership as centralized decision-making, which is proven ineffective in smart city transition management; rather, municipal governments should act as "principal orchestrators" (Gupta et al., 2020, p. 9) who mediate among different powers, interests, and priorities, without imposing a centralized form of power.

Finally, much emphasis has been placed on the collaborative tools and spaces that actors can use to sustain the formation of cross-sector partnerships. To enable active participation among residents in the definition of strategic orientations and design of smart city services, for example, municipal governments can resort to tools traditionally employed for enhancing citizen engagement (such as civic budgets, consultations, and workshops) (Masik et al., 2021; Stratigea et al., 2015). Crowdsourcing techniques and open data initiatives (like hackathons and data-driven competitions) have also been recommended to boost the involvement of citizens and entrepreneurs in smart city initiatives (Mora et al., 2019b; Sarma and Sunny, 2017; Stratigea et al., 2015). Moreover, scholars have emphasized the vital role of collaboration spaces (such as incubators, accelerators, and living labs) in facilitating co-creation and testing of digital services in multi-stakeholder settings (Camboim et al., 2019; Nilssen, 2019).

However, empirical evidence on the actual effectiveness of these collaborative tools and spaces remains limited. Studies focusing on European cities have concluded that public consultations are more engaging than workshops and public meetings, whereas data initiatives in Japan and North America have been criticized for being just once-off actions that only benefit citizens with digital skills (Barns, 2016; Mora et al., 2019b; Trencher, 2019). In response to this critique, smart city research has emphasized the need to provide citizens with measures apt to enhance their digital skills, including training. Without ad-hoc interventions to stimulate active citizen participation, smart city transitions risk treating residents just as "sources of data" (Johnson et al., 2020, p. 7). Commentaries are also offered on the importance of developing clear communication strategies to raise public awareness about smart city transitions and ensure that cross-sector partnerships interact with all relevant stakeholders (Chong et al., 2018; Leitheiser and Follmann, 2020). Smart city research implies that providing the public with a clear understanding of local smart city transition plans and activities is of utmost importance in ensuring higher levels of active participation (De Guimarães et al., 2020; Viale Pereira et al., 2017).

4.3. *Urban digital innovation*

Digital Infrastructure and *Digital Services* combine to form the last governance dimension in our framework. Together, they refer to the governance mechanisms associated with the assemblage and management of new digital services and the information architecture that is required to deliver them.

4.3.1. *Digital infrastructure*

Digital infrastructure assets enable urban settings to collect, store, transfer, elaborate, and visualize data that can be used to design and deliver digital services in response to sustainable development needs. When examining data collection in urban environments, the literature on smart city governance typically refers to sensor networks that are formed by a combination of multiple devices (such as radio-frequency identification tags and smart meters) and interfaces (such as communication interfaces and cloud interfaces) (Kumar et al., 2020). These infrastructures, and the data they capture, are critical resources in the formation of innovation partnerships; they enable a timely and constant exchange of information that could enhance trust and accountability among the partners (Chambers and Evans, 2020; Velsberg et al., 2020). However, regulating the functioning of these infrastructures and data management practices is difficult. Technical regulations and standards that address security and privacy issues are needed; however, public sector organizations struggle to introduce and orchestrate these directives across different levels of administration (Sharma et al., 2020).

The collection and transmission of data requires the availability of fast, reliable, and capillary broadband networks. These infrastructures have been described as "the technical basis for the provision of […] public smart services" (Wirtz et al., 2020, p. 510); thus, affecting how and what digital services can be implemented in the urban innovation ecosystem. They are also seen as contributing toward shaping cross-sector partnerships, because entrepreneurs have been reported to consider broadband availability as a primary factor in selecting the location for their business (Sarma and Sunny, 2017). Expanding the availability of broadband networks has, therefore, recurred in the literature as a priority for sustainable smart city transitions, with some authors identifying municipally owned wireless networks as one of the most promising tools in bridging the digital divide (Anthopoulos, 2017; Ylipulli et al., 2014).

Finally, the smart city literature has stressed the importance of data platforms, referring to both virtual and physical assets supporting the storage, sharing, and analysis of data. Of utmost importance in the governance of data platforms is the quality and security of datasets, which directly affects the extent to which data can be reused for digital services (Abella et al., 2017; Van Winden & Van Den Buuse, 2017). The approach to data platform management and assemblage directly influences the development of smart city transitions (Ford and Wolf, 2020; Wirtz et al., 2020). Across several European cities, in San Francisco, United States, and in Singapore, for example, the availability of a publicly accessible database and open data platforms have been found to facilitate the co-creation of new digital services (Mora et al., 2019b; Wirtz et al., 2020). Conversely, the coexistence, within urban innovation ecosystems, of multiple datasets owned by different entities has emerged as a major constraint to urban innovation, exacerbated by the lack of coordination within the public sector (Barns et al., 2017) and the lack of appropriate cooperation agreements ruling data sharing (Giest, 2017; Viale Pereira et al., 2017).

Research examining data platforms frequently introduce data visualization – through dashboards or other visualization tools – as another relevant activity that is expected to improve decision-making and enable bottom-up action in the urban innovation ecosystem (Trencher, 2019). Some studies, however, have questioned the effectiveness of existing visualization tools. For example, in Oulu, Finland, residents do not find the data provided by dashboards useful, because "the elderly […] do not need the information offered by the displays, and the young adults thought they can get the same content by using, for example, a smartphone" (Ylipulli et al., 2014, p. 156). This evidence has triggered a debate on how to better design data visualization tools by taking into consideration the sociotechnical and emotional aspects that the interaction of the public with these digital instruments entail (Kitchin et al., 2016; Ylipulli et al., 2014).

4.3.2. Digital services

From a governance perspective, digital services in smart city transitions are discussed by focusing on business models and the service design cycle. Business models represent a cause for concern in the smart city literature; several studies discuss smart city projects that did not survive post-experimental phases owing to the use of unsustainable business models (Bresciani et al., 2018; Grossi and Pianezzi, 2017). While examining the factors constraining business model innovation in urban innovation ecosystems, available studies associate private companies with path dependencies and organizational rigidities (Brock et al., 2019), whereas the public sector seems to be affected by the lack of skilled staff and administrative coordination (Fromhold-Eisebith and Eisebith, 2019). Looking at the lessons learned from Eindhoven, Netherlands, and Florence, Italy, these limitations can be overcome by embracing open innovation models and a customer-driven approach to digital service design and implementation (Abbate et al., 2019; Brock et al., 2019). The literature has emphasized the need to adopt business models that are tailored to the characteristics of and developed in parallel with local digital infrastructures (Abbate et al., 2019; Zhang et al., 2020b).

Research has illustrated many smart city projects where digital services were conceived and managed as isolated experiments, mainly because the technical standards were lacking and integration among digital infrastructure systems was limited (Abbate et al., 2019; Giest, 2017). Knowledge-sharing mechanisms can offer a solution to these challenges, but intellectual property rights may pose a constraint on the circulation of ideas and knowledge across different cities and partners (Van Winden & Van Den Buuse, 2017; Viale Pereira et al., 2017). Therefore, to sustain scale-up operations, scholars recommend creating urban innovation ecosystems where start-ups and larger corporations can cooperate in developing scalable digital services, combining their respective strengths (Sarma and Sunny, 2017).

In addition to discussing the sustainability and scalability of business models, the smart city literature also proposes a set of principles that should be incorporated in the design cycle of digital services in the context of smart city transitions. Significant emphasis has been placed on creating services that respect privacy and are secure and accessible to all citizens. Relying on technical regulations, however, is insufficient in addressing concerns around data protection and cybersecurity (Belanche-Gracia et al., 2015; Lim et al., 2018); cooperation between municipal governments and technology vendors is also needed to proactively prevent cyberattacks and embed data protection in the design of the digital services introduced via smart city projects (Li and Liao, 2018). This approach may entail additional costs but improves service uptake and the sustainability of technological solutions (Vandercruysse et al., 2020).

The service design cycle should consider all factors determining different levels of technology adoption (such as social norms, ongoing digital divides, and cultural influences) to ensure that digital services are accessible to all residents (Baudier et al., 2020; Kong and Woods, 2018; Zhang et al., 2020a). Actions should be taken to countervail negative perceptions of privacy and security in local communities. For example, research conducted in Spanish and Kenyan cities suggests that the local ownership of digital services reduces privacy concerns (Belanche-Gracia et al., 2015; Chambers and Evans, 2020). Moreover, digital adoption can be boosted by launching a unified service portal (such as a municipal website, smartcard system, or mobile app). This is expected to enhance the user friendliness and efficiency of digital services (Yu et al., 2019); although, research on Dutch smart city transition cases conclude that this approach may not be cost-effective for smaller cities (Kuk and Janssen, 2011).

To ensure that digital services are responsive to local needs and mindful of different users' perceptions and experiences of urban digital innovation, the involvement of citizens in the service design cycle has been highly recommended (Kumar et al., 2020; Mosannenzadeh et al., 2017). The participation of citizens in idea generation and prototyping phases can enhance the quality of digital services, for example, by helping identify design flaws. This assertion is supported by evidence sourced from multiple case studies. In Milton Keynes, UK, and Santiago del Chile, Chile, participatory prototyping has allowed the redesign of smart mobility applications (Tironi and Valderrama, 2018; Valdez et al., 2018), whereas in Rotterdam, Netherlands, and Berlin, Germany, it has facilitated cross-sector collaborations and paved the way for the co-creation of new services (Kraus et al., 2015; Van Waart et al., 2016). Collecting the feedback of residents after the launch of a new service has also emerged as a good practice: in Jakarta, Indonesia, and Milan, Italy, the use of mobile apps to assess user satisfaction has contributed to developing new and more effective digital services (Allen et al., 2020; Gagliardi et al., 2017).

5. Discussion and conclusions

The smart city concept does not represent a status or a product, but it should be understood as an urban innovation process that involves a sustainability transition where managerial and policy efforts mix with technological development. Accordingly, we consider smart city transitions as naturally connected to the field of innovation management, where they have surprisingly received limited attention. Drawing upon this rationale, our study has synthesized and systematized the state-of-the-art on the governance of smart city transitions by building on the robust and diversified knowledge base offered by business and management studies. The objective is to expand our understanding of smart city transitions and their governance dimensions from an innovation management perspective. This focus has helped clarify how the relatively little-discussed managerial and policy aspects accompany the already much-examined technological issues that influence smart city transitions and the urban innovation processes they trigger. Therefore, our knowledge is enhanced from both a theoretical and a practical perspective.

The theoretical and practical implications of our review, as well as recommendations for future research, are outlined in the subsections below. These recommendations address the knowledge gaps uncovered by the analysis and discuss how theoretical perspectives developed in the framework of innovation management studies may support the examination of relevant enquiries (see Table 3).

5.1. Theoretical and practical implications

From a theoretical perspective, we have expanded the theoretical framing of smart city transitions as innovation processes (Crossan and Apaydin, 2010). Our systematic investigation shows that in "addition to contemporary smart city literature, other literature strands [such as

Table 3
Summary of the findings: recommended governance practices extracted from the smart city literature and future research agenda.

GOVERNANCE FRAMEWORK Components	RECCOMENDED GOVERNANCE PRACTICES	RELEVANT AREAS OF, FUTURE SCIENTIFIC ENQUIRY
C1.1.1 Administrative structure	• Overcoming administrative silos and the fragmentation of powers and responsibilities across different government levels by establishing smart city units that oversee and coordinate smart-city-related initiatives at the local level.	• How should smart city units be structured and managed? • What are the structural reforms needed to enhance coordination within and across the public organizations involved in smart city transitions?
C1.1.2 Culture	• Nurturing a culture of (open) innovation and experimentation in the public sector.	• How can cultural changes be triggered in public sector organizations so that innovation mindsets can flourish? • How can sustainable forms of public entrepreneurship be supported?
C1.1.3 Internal capabilities	• Bridging knowledge gaps in the public sector by promoting upskilling initiatives.	• What are the skills gaps that affect the capability of public sector officials to govern smart city initiatives?
	•Introducing measures for mitigating resource scarcity issues and ensure that the human, financial, and technological resources needed at the municipal level to support smart city projects and transitions are available.	• What are the funding strategies and policies that can best support smart city transitions in conditions of economic constraints?
C1.2.1 Public procurement of technological innovation	• Introducing innovative procurement methods, such as long-flexible contracts, that fits with the implementation requirements of smart city projects.	• What alternative procurement methods can be adopted to support smart city projects and transitions?
C1.2.2 Technical regulations and standards	• Boosting harmonization and coordination among the multiple technical regulations and standards produced by different regulatory bodies.	• How can harmonized technical regulations and standards be developed and enforced? • How can emerging issues of digital rights and ethics of technology be integrated in the technical regulations and standards for smart city transitions? • How should technical regulations and standards be shaped so that barriers to the entry of new technology providers are not created?
C1.2.3 Technological innovation policies	• Adopting national policies (especially funding schemes) that facilitate collaborative governance (vertical and horizontal) and help municipal governments to develop a culture of innovation and experimentation.	• What is the optimal policy mix for supporting smart city transition efforts?
	• Avoiding fragmentation of local policies for smart city transitions.	• How can multi-level policy formulation be coordinated?

Table 3 (*continued*)

GOVERNANCE FRAMEWORK Components	RECCOMENDED GOVERNANCE PRACTICES	RELEVANT AREAS OF, FUTURE SCIENTIFIC ENQUIRY
C1.3.1 Implementation strategies	• Operationalizing objectives and priorities by setting clear implementation strategies, where a portfolio approach to smart city projects is recommended.	• What is the optimal mix of public-private funding to support smart city transitions?
	• Avoiding technological solutionism by adopting a place-based approach to the selection of digital solutions to be implemented in smart city projects. • Defining ad-hoc monitoring systems and performance evaluation measures to assess smart city projects.	• How can the trade-off between the demand for tailored solutions and the supply of standardized technologies be managed without compromising scale-up operations? • How does technological path dependencies affect technology selection phases in smart city projects? • What are the best strategies for introducing a portfolio approach to smart city projects? • How should ad-hoc monitoring systems and performance evaluation measures for smart city transitions be structured?
C1.3.2 Strategic orientation	• Coordinating the collective actions of urban innovation ecosystems by formalizing objectives and priorities of the smart city transition in official strategic documents (for example, strategic plans or vision statements).	• How can we ensure that strategic documents for sustaining smart city transition processes are up to date with changes in local-context conditions and technological landscapes?
	• Leveraging participatory and inclusive co-design processes to formulate a long-term vision on smart city transitions that is tailored to local-context conditions.	• What methods are best suited to formulate long-term, strategic orientations considering the (potentially conflicting) needs of different local stakeholders?
C2.1.1 Cross-sector partnerships	• Improving the responsiveness of smart city projects to local development needs by adopting a quadruple-helix approach to the development of urban innovation ecosystems.	• How can public sector organizations encourage the active participation of citizens in smart city initiatives? • What mechanisms can be introduced in smart city projects to cope with tensions among project partners? • How does the configuration of cross-sector and intra-sector partnerships evolve during the development of smart city projects and transitions?
C2.1.2 Intra-sector partnerships	• Setting nationwide policies and benchmarking tools to help local authorities align their goals and actions in the context of smart city transitions.	• What are the reforms that can facilitate collaboration within the public sector?
	• Increasing the coordination among the different administrations	• How can intra-sector partnerships be facilitated within the private

(*continued on next page*)

Table 3 (*continued*)

GOVERNANCE FRAMEWORK Components	RECCOMENDED GOVERNANCE PRACTICES	RELEVANT AREAS OF, FUTURE SCIENTIFIC ENQUIRY
	involved in smart city projects.	sector and in civil society organizations?
C2.2.1 Collaborative tools and spaces	• Employing a mix of collaborative tools and spaces that considers the skillsets and competences of different target audiences.	• To what extent are existing collaborative tools and spaces effective in enabling inclusive co-creation processes?
	• Ensuring that adequate training and support are in place to tackle existing barriers to inclusive co-creation processes.	• What are the digital skills that citizens require to actively participate in smart city projects and benefit from their outcomes?
C2.2.2 Consensus building	• Engaging with local and supralocal knowledge-sharing networks that facilitate the acquisition and dissemination of key lessons on smart city transitions.	• How can trust relationships be built without compromising cooperation agreements?
	• Managing innovation partnerships by replacing (when possible) bureaucratic control measures with trust-based mechanisms.	• How can sensemaking processes be organized during smart city projects?
	• Ensuring political commitment and public sector leadership throughout the different phases of smart city transitions.	• How can municipal leadership be ensured without stifling bottom-up innovation?
		• What leadership styles best support innovation partnerships in smart city transitions?
		• How can we mitigate the disruptions to smart city transitions that political instability can generate?
C2.2.3 Cooperation agreements	• Adopting dynamic cooperation agreements that adapt to the evolving needs of smart city projects and transition processes.	• How can urban development actors structure and manage dynamic cooperation agreements?
		• How do existing cooperation agreements perform in the context of different smart city projects?
C3.1.1 Broadband networks	• Ensuring that everyone has access to affordable, fast, and resilient broadband networks.	• How should the rollout and operations of citywide broadband networks be managed?
		• How can evolving connectivity needs be constantly monitored and addressed?
C3.1.2 Data platforms	• Incentivizing the use of publicly accessible datasets to boost the co-creation of new digital services and improve the maintenance of existing ones.	• How can we implement data validation and verification processes that ensure the high quality and accuracy of datasets?
	• Designing user-friendly data visualization tools by considering social, emotional, and cultural aspects.	• How should the outline of data sharing agreements between innovation partners be approached?
C3.1.3 Sensor networks	• Developing standards and technical regulations for urban data collection that address the security and privacy issues affecting data management practices.	• How should the rollout, maintenance, and operations of sensors networks be managed?
		• How can the long-term cost-effectiveness and environmental impact of sensors networks be evaluated?
C3.2.1 Business model	• Creating urban innovation ecosystems where municipal governments, citizens, start-ups, and large corporations can easily share knowledge and collaborate in developing sustainable and scalable digital services.	• How can knowledge transfer among innovation partners be incentivized while intellectual property rights are enforced?
		• How can business models be innovated to make the scalability and replicability of digital services easier?
C3.2.2 Service development cycle	• Increasing the user-friendliness and accessibility of digital services by offering unified service portal solutions.	• How can secure and privacy-by-default digital services be designed?
	• Adopting co-creation practices throughout the service design cycle to enhance the security of digital services and their responsiveness to evolving urban sustainability needs.	• How can public and private actors sustain the active participation of citizens in the design and experimentation phases of digital services?
		• How can different responses to digital divides be implemented, monitored, and assessed?
		• How can the costs and benefits of unified service portals be evaluated?

innovation studies] may also be used to explore smart city governance" (Ooms et al., 2020, p. 1227). Accordingly, we have identified and examined the governance dimensions of smart city transitions by recalling key aspects of innovation management literature. Moreover, we have also offered a comprehensive understanding of what is currently known about these governance dimensions, including observations on their interdependencies. This study represents one of the first attempts (see Lee et al., 2014 and Ooms et al., 2020 for prior conceptualizations) to structure a comprehensive framework that details the configuration of multidimensional components that should be considered when adopting an innovation-management approach to smart city governance (see Fig. 2).

This study also has practical implications. By exposing the key dimensions of smart city transitions and how they are structured, our governance framework can help the political and executive bodies of public sector organizations – who are at the forefront of these complex urban innovation processes – to appreciate the complexity of smart city transitions and the sociotechnical transformations they entail. Becoming aware of these complexities can stimulate public sector organizations to move beyond technocentric approaches to smart city transitions and one-size-fits-all mentalities. This insight is complemented by empirically grounded recommendations on governance practices (see Table 3) that can help improve the managerial capability of the organizations and individuals operating in the smart city domain. For example, Section 4.2 discusses several tools and mechanisms that can be used to achieve consensus building and strengthen collaborations. Section 4.3 lists principles that can improve the quality, inclusivity, and sustainability of the digital services introduced during smart city projects.

5.2. Future research agenda

In addition to dimension-specific knowledge gaps (see next sections), we have also identified three major gaps that affect research on all governance areas. First, the literature provides insights on the governance of smart city transitions by looking at experiences developed worldwide. However, scholars have manifested a strong preference for European case studies, whereas a more limited body of knowledge can be sourced from empirical settings located in Africa, Asia, the Americas, and Oceania. Second, research has predominantly investigated large cities over small-scale urban areas. To overcome this theory-practice gap, smart city researchers should consider strengthening the empirical base of smart city research, which can be achieved through replication studies "that put published empirical results to an additional empirical test" (Block and Kuckertz, 2018, p. 355) in overlooked urban contexts. Replication studies can detect if prior findings repeat, expanding our understanding of the effects that changes in geographies and contextual factors may have on the recommended governance practices that we have sourced from the smart city literature. Third, insufficient data are currently available to obtain the precise series of steps describing the sequential processing of each governance dimension and lower-level components (Ooms et al., 2020). It is also impossible to fully assess their interplay or to measure the intensity of their relationships. Generating this knowledge base would enhance the capability of urban development actors to manage smart city transitions, but more research is needed to produce a process representation, where the main challenge is represented by the place-based nature of smart city transitions. We expect development processes to depend upon local socio-technical conditions. If used as an analytical tool, our governance framework can be instrumental in supporting comparative research efforts.

5.2.1. Institutional context for urban innovation

5.2.1.1. Public sector setting. Smart city research has stressed the importance of establishing dedicated units that are tasked with overseeing smart city initiatives at the municipal level. This recommendation recalls the relevance of teams in guiding innovation projects (Chen et al., 2013). Nevertheless, there is little evidence and practical knowledge of the organizational structure that should be adopted to set up these entities (e.g., centralized, formalized, or autonomous) (Vendrell-Herrero et al., 2021), the leadership style they should rely on (e.g., directive leadership or participative leadership) (Somech, 2006) and the tools and techniques they should deploy to sustain the development of digital solutions to urban challenges (e.g. brainstorming sessions, design thinking, agile, etc.) (Seidel and Fixson, 2013). Innovation is predominantly driven by innovation efforts, but it is well-known in the innovation management literature that organizing and analyzing the characteristics that influence team performance is key to attaining the desired goals (Love and Roper, 2009; Thamhain, 1990). Moreover, it should be noted that the answers to the abovementioned questions may not be univocal. As evidenced in research on innovation projects (Gupta et al., 2020), multilevel contextual factors may affect how smart city teams operate, and these factors need to be examined.

Scholars also emphasize the importance of developing a culture of experimentation and innovation in the public sector (Wynen et al., 2014), and smart city projects are playing a key role in sustaining this cultural shift. However, smart city research does not explain how to best promote structural and behavioral modifications that can boost cultural changes and entrepreneurial mindsets in public sector organizations. A notable exception is the study conducted by Fastenrath and Coenen (2021), which underlines the importance of governance experimentation to "break down bureaucratic silos and innovate beyond conventional predict-then-act planning approaches" (139). Upskilling initiatives for public sector officials may also be conducive toward developing a culture of experimentation and digital innovation, as well as overcoming the lack of qualified human resources capable of managing the complexity of innovation projects (Kuziemski and Misuraca, 2020). However, the smart city literature does not clarify what skills are needed, whom these skills can be acquired from, and how upskilling should be put in place in the public sector. Further research is required to unveil the reforms that are needed to make the public sector more supportive of smart city transitions.

5.2.1.2. Policies and regulations. Researchers tend to distinguish relevant digital innovation policies by focusing on their content (data, security, etc.) or geographic scope (local and national). Yet, the smart city literature has largely overlooked how different policies and regulations complement or contradict each other in smart city transitions. Additional efforts are needed to define an optimal policy mix, which should consider the combined effects of multilevel governance. Further consideration, for example, should be given to international regulations (European data regulation, international standards, etc.) and their coordination with local and national policies, whose impact on smart city transitions is yet to be examined. As these transitions can be considered urban innovation processes, further engagement with the literature on innovation policies (e.g., demand-pull, technology-push, regulatory push/pull) (Nemet, 2009) may help expand our understanding on the role of regulations in the smart city domain. Moreover, although funding sources sensibly matter for innovation intensity and performance (Czarnitzki and Lopes-Bento, 2014), an in-depth examination of funding schemes for supporting smart city transitions has been surprisingly overlooked.

The use of public demand (i.e., procurement) to spur innovation has seen a very significant increase in political support (Edler and Georghiou, 2007). Nonetheless, current procurement practices for smart city projects and transitions seem mismatched. A critical area of investigation relates to innovative procurement solutions for relaxing strict bureaucratic regulations (e.g., long flexible contracts), which may become an obstacle to smart city transitions, while assuring transparency and an efficient allocation of public money. In this context, identifying strategies for putting stewardship into practice and limiting the downsides of less stringent procurement policies should be prioritized. In innovative public procurement such as procurement processes of non-standardized products (Torvinen and Ulkuniemi, 2016) like smart city technologies, knowledge about the needs of procurers (technical, social, environmental, etc.) should be transferred to potential suppliers, and suppliers' knowledge of possible technological solutions should be transferred back to procurers. In the framework of sustainable smart city transitions, how this knowledge transfer should be managed remains unclear, and from this perspective, innovative public procurement has heavier requirements for interactions between procurers and potential suppliers. However, there have been no smart city-related studies thus far.

Finally, technical standards are particularly relevant in the regulation of competition and innovation (Drahos and Maher, 2004). There are dynamic feedback effects concerning technical standards; they influence the economic performance of innovative industries, which may affect the determination of technology standards through standards organizations and government regulation (Spulber, 2013). This also refers to (digital) technologies to be adopted in smart city projects. However, how to develop and enforce harmonized regulations and standards in smart city transitions, especially reconciling standards at the local and supralocal levels, remain critical issues.

5.2.1.3. Strategic agenda. The smart city literature has emphasized the need to set clear strategic plans and vision statements that seek to align smart city projects' goals and resources with those of the municipal governments and make them consistent with local needs and resources. This should be a long-term vision that takes into account technological updates and evolving sociotechnical circumstances at the local level. For any (complex) innovation project, strategic orientations are required (Paladino, 2007). An integrated people-centric and citizen-driven smart city vision, supported by political leaders and developed through an open and inclusive collaborative process, can be helpful. This is in line with the relatively recent concept of quadruple-helix innovation (Afonso et al., 2012). However, a broader analysis of the methods that can be used to define long-term strategic orientations considering contextual circumstances and different evolutionary scenarios have been overlooked in the smart city literature. One way to overcome this issue is by linking the smart city literature with, for instance, innovation studies that examine the quadruple-helix perspective (Gouvea et al., 2013; McAdam et al., 2016).

Implementation strategies must follow strategic orientations. This requires formulating clear criteria for selecting technological solutions, selecting the planning mechanisms necessary to leverage synergies and pool funding across different projects, and developing the metrics and methods for the assessment of smart city initiatives across their life cycle. However, scholars have shown that it is unclear how technology selection should be pursued in smart city projects, while considering path dependencies and the management of the trade-off between the demand for tailored solutions and the supply of standardized technologies. Further research is needed in this area, where issues concerning technology affordances, cost-benefit analyses, and user-acceptance have been overlooked. To address these gaps, the innovation management literature (Chatterjee et al., 2020; Kim et al., 2021; Yi et al., 2006) and studies on technology scouting and assessment may provide useful insights (Rohrbeck, 2010; Van Eijndhoven, 1997). Smart city research should also focus more on the identification of methods and tools that can help cope with the obsolescence and maintenance of smart city technologies – two interrelated topics that are insufficiently covered in the smart city literature. Moreover, while a portfolio approach to the planning of smart city projects is recommended to leverage synergies and pool resources, the best strategies to manage this approach have not been revealed. Additional knowledge should be provided on balancing top-down and bottom-up approaches in the implementation of smart city transitions and the extent to which they should be adopted in the different phases of the process. Finally, orientations on the optimal funding mix (across multiple projects) are missing. Alternative funding mechanisms that are examined in innovation studies, such as crowdfunding (Messeni Petruzzelli et al., 2019), are also mentioned in smart city literature, but further empirical evidence is necessary to clarify whether and how they can become an effective tool for sustaining urban innovation processes.

Challenges concerning monitoring processes in the smart city areas also come into play due to the lack of metrics and methods to assess outcomes, which open a relevant line of inquiry. The smart city debate does not have any robust discussion on how the monitoring process should be implemented, who should oversee it, and how to handle updating strategic documents when changes to the strategic agenda are needed. The literature on public sector innovation may provide useful insights on overcoming these gaps and developing ad-hoc performance indicators for smart city transitions (Bovaird and Loeffler, 2007; Twizeyimana and Andersson, 2019).

5.2.2. Urban innovation ecosystem

5.2.2.1. Innovation partnerships. Smart city transitions are collaborative processes in which partnerships play a pivotal role. Most scholars recommend forming cross-sector partnerships, following the quadruple-helix innovation concept, to mitigate power imbalances and co-create digital services in cross-sector collaborative ecosystems. Although this notion has become central in smart city discourses, research on smart city transitions has not considered that quadruple-helix approaches to innovation are contingent upon the types of innovations and their development stages (Del Giudice et al., 2017). This one-size-fits-all mentality is accompanied by little guidance on how multi-stakeholder collaboration should be enforced and managed. Examples of critical, yet overlooked, matters include the following: the stages in which different stakeholders should be involved, the ways in which tensions among partners can be managed, how incentives and goals of different partners can be aligned, and how a fair balance between the interests of different partners can be ensured. Additionally, there is a lot of emphasis on citizen participation in smart city literature, but limited insights are offered on when and to what extent this involvement should take place and on how to ensure the active participation of citizens.

More attention should also be paid to intra-sector partnerships; the analysis has been limited to the coordination of public entities, without specifying the collaborative agreements that are or should be in place and what reforms are needed to facilitate these collaborations. Moreover, it is widely acknowledged that coordinating actions at different administrative levels requires trust mechanisms and the support of nationwide policies. However, it is unclear what mechanisms are most effective in building trust among partners. Drawing on the literature on multilevel governance in the context of innovative policy development (Green and Orton, 2012), we invite future research to explore ways to coordinate national, regional, and municipal interventions for smart city transitions. Equally important is a broader investment in the study of intra-sector collaboration in the private sector and civil society.

5.2.2.2. Innovation partnership formation. Despite the emphasis placed on partnerships as a cornerstone of smart city transitions, the literature lacks comprehensive investigations of the cooperation agreements supporting the diverse alliances formed in urban innovation ecosystems. Their arrangements and implications have not been discussed in detail. Key avenues for future research relate to the structure and management of cooperation agreements for intra-sector and quadruple-helix partnerships, as well as the design and implementation of dynamic cooperation agreements. Moreover, empirical analyses that compare cooperation agreements currently in use are missing.

Having acknowledged the risks of collaborative tensions that undermine the governance of smart city transitions, the literature has identified a wide set of tools to support consensus-building; although, some important challenges have been neglected. First, conceptual ambiguity issues remain as the literature does not inform collaborating actors on how they can or should develop shared interpretations of smart city projects and the role that supralocal organizations can play in facilitating or inhibiting the sensemaking processes. Second, in most cases, it is unclear how trust relationships can be built without compromising the openness and inclusivity of cooperation agreements, despite effective collaborations being usually based on stewardship and trust (facilitated by horizontal coordination mechanisms). Third, municipal governments often act as orchestrators of smart city transitions, with strong political support backing their leadership. Therefore, future studies are expected to identify leadership competences that are necessary to support smart city partnerships and ways to enforce municipal leadership without stifling bottom-up innovation, promote a culture favorable to smart city transitions in the political landscape, and neutralize the effects of political instability and power imbalances. Finally, the smart city literature offers limited discussion on knowledge-sharing across different sectors; although, it recognizes the risk of having knowledge spillovers that discourage cross-sector collaboration.

In innovation projects (Michaelides et al., 2013; Ungureanu et al., 2021), collaborative tools and spaces are recognized as essential to facilitate the formation of innovation partnerships and make them less subject to opportunistic behaviors. Nonetheless, comparative analyses of different collaborative tools and spaces are missing in the smart city context, which should also consider potential complementary and substituting effects as the use of a holistic mix of tools is suggested. Moreover, as most of the instruments currently used are digital, it is important to understand how to equip individuals, particularly the groups deeply affected by digital divides, with the skillsets needed to tackle existing barriers to digital inclusion and citizen empowerment in smart city projects. How to create and manage the most effective collaborative spaces has been a controversial topic in innovation studies (Montanari et al., 2021), yet this has been disregarded in the smart city literature. Only superficial consideration has been given to their functioning. With this in mind, future academic works may rely on the well-established literature on collaborations for innovation to delve into issues such as proximity, types of contracts, partner selection tools, and accountability measures (Geum et al., 2013; Kloyer and Scholderer, 2012; Knoben and Oerlemans, 2006).

5.2.3. *Urban digital innovation*

5.2.3.1. Digital infrastructure. Despite their vital role in smart city transitions, the governance of sensors and broadband networks remain largely unexplored. In relation to the former, the literature has mainly highlighted the need for technical regulations and standards to address security and privacy issues. However, detailed empirical investigations on how sensors networks should be designed and managed in urban settings is still lacking. Similarly, there has been little discussion on the impact different ownership and funding models have on the development of broadband infrastructures, despite being a widely debated subject matter of investigation among telecommunications scholars (see Gerli et al., 2018; Oughton et al., 2022; Po-An Hsieh et al., 2012). For example, in smart city research, municipally owned networks are praised as a potential solution to patchy urban broadband coverage, but further research is needed to empirically assess their implications for smart city transitions.

Data platforms constitute another key component in making cities smart. Notwithstanding, there is a paucity of research on the ownership, control, and governance of (open) data platforms and related elements (e.g., data ingestion, warehouse, lakehouse, business intelligence, data transformation, data storage, and privacy). This gap could be addressed by engaging with the literature on data governance (Young, 2020) and looking for the optimal mix of policies and standards to regulate the complexity of data platforms. In the design of data platforms and data visualization tools (e.g., dashboards and displays), for example, it is important to ensure that front-end interfaces allow users to interact easily with the system; albeit, the topic is neglected in smart city literature, and user-friendliness depends upon a combination of socio-technical factors, including emotions (Gerli et al., 2022).

5.2.3.2. Digital services. Privacy and security issues have been widely analyzed in the literature on open and data-based innovation (Bleier et al., 2020), yet their role in the context of smart city transitions requires further consideration. Emphasis is placed on the need to encompass cybersecurity and data protection in digital services, but more research is needed to understand how to implement privacy-by-default digital services and exploit the potential of big-data solutions without impinging on the privacy of citizens (Anisetti et al., 2018).

To develop digital services that maximize public value, the innovation management literature suggests adopting co-creation methods (Chaudhuri et al., 2022; Pauliuk et al., 2022). The active participation of users is expected to enhance the user-friendliness of digital services and their responsiveness to local needs, while mitigating digital divides by addressing existing psychological and cognitive obstacles to technology adoption (Sjödin et al., 2020). The importance of co-design approaches is widely recognized in the smart city literature, with multiple collaborative tools and spaces being identified as potentially beneficial. Nevertheless, it remains unclear what strategies can best support the collection of feedback from citizens in design stages and their active participation. This review provides a clear scope for future studies to compare and assess the impact of using different participatory tools on co-design processes. Specific attention should be paid to the ability of these tools to tackle the different forms of digital divides existing in urban setting and ensure wide participatory processes where the voice of groups typically marginalized can be heard (Lythreatis et al., 2022).

Business model innovation is an additional knowledge area that requires further consideration in the literature on smart city transitions. Based on our review, implementing place-based solutions that are scalable and replicable has emerged as a critical challenge. The growing literature on digital business models may provide valuable advice on how to bridge this knowledge gap (Huikkola et al., 2022; Wirtz, 2019). Comparative and empirical analyses of business models can be useful in identifying solutions that could also be adapted to the context of smart city transitions and urban innovation ecosystems. For example, the innovation management literature endorses an open innovation perspective to business model innovation (Huang et al., 2013), which aligns with the emphasis on quadruple-helix innovation that recurs in the smart city literature. However, additional research efforts are necessary to explore how smart city partners can form a "healthy community and ecosystem" for open innovation (Shaikh and Levina, 2019, p. 2) without hindering the knowledge transfer and systems integration requirements (Gurca et al., 2021) of smart city project developments.

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Data availability

Data will be made available on request.

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