Innovation and Smart Cities Research: A Review and Future Directions

Boumediene Ramdani and Peter Kawalek

Abstract This chapter aims to review existing evidence and map research on innovation in smart cities. Based on data from 822 articles and chapters, bibliometric analyses were performed to capture descriptive statistics and key themes of this field of research. The results of our descriptive analysis show that interest in this field of research is increasing, and substantial contributions have been made in the past 12 years. Moreover, the results from co-citation analysis show that innovation in smart city research is grounded in four clusters: open, urban, sustainable, and digital innovation. Key contributions within each theme will be discussed, and future research opportunities will be highlighted.

Keywords Smart cities · Innovation · Review · Bibliometric analysis

1 Introduction

Smart cities are defined as "initiatives or approaches that effectively leverage digitalisation to boost citizen well-being and deliver more efficient, sustainable and inclusive urban services and environments as part of a collaborative, multistakeholder process" (OECD, 2018). With the proliferation of smart city initiatives around the world, greater attention has been given to innovation as a novel way to build new smarter cities or regenerate older ones. Innovation can be embedded in every stage of development, from planning to construction to management and operations,

B. Ramdani (✉)
Centre for Entrepreneurship and Organizational Excellence, College of Business & Economics, Qatar University, Doha, Qatar
e-mail: b.ramdani@qu.edu.qa

P. Kawalek
Centre for Information Management, School of Business & Economics, Loughborough University, Loughborough, UK
e-mail: P.Kawalek@lboro.ac.uk

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implementation, and support. A recent UNDP report (2021) claims that smart innovations are shaping urban cities across the globe by addressing citizen priorities.

Innovation in smart city research is divided between a technocentric perspective originating from the American business community and a holistic perspective instigated from European institutions (Mora et al., 2017). Advocates of the technocentric perspective suggest that digital innovation should be at the heart of successful smart city initiatives (Cardullo & Kitchin, 2019; Yang et al., 2017), whereas supporters of the holistic perspective claim that other urban innovations should be considered in addition to digital innovation to build successful smart cities (Yigitcanlar et al., 2018; Batty et al., 2012a, b). Building smart cities involves not only technological changes but also changes in regulations, infrastructure, industrial networks, practices, and culture (Geels, 2002). Therefore, other types of innovation may be necessary for these changes to take place. However, it is unclear what these innovations are and what evidence exists to support them.

This chapter aims to review existing evidence on innovation in smart city research. This is timely for several reasons. First, smart city research is interdisciplinary, and existing reviews do not tackle innovation head-on. Second, this review will bring together key contributions in this field of research to shed light on how urban problems have been resolved. Third, this review is timely to show where future research efforts should focus to move this area of research forward. Using the Clarivate Analytics Web of Science (WoS) database, we will identify the key publications and cluster them to show existing evidence.

The remainder of this chapter proceeds as follows. The next section covers the research method (Sect. 2). Section 3 presents the results of our analyses. The following section (Sect. 4) discusses the main findings. Finally, Section 5 concludes the chapter, and Sect. 6 discusses future research on smart city innovation.

2 Research Method

Following the standard workflow of science mapping (Zupic & Čater, 2015), we performed bibliometric analyses using the five-stage workflow recommended by Aria and Cuccurullo (2017). First, this review aims to map the existing evidence on innovation and smart city research using the ISI Web of Science (WoS) database. Second, data were collected from the WoS database using search strings ("innovation" and "smart cit*"). Our search returned 1213 documents. By limiting our search criteria to only articles, reviews, and book chapters in English, we ended up with 822 documents (770 articles, 48 reviews, and 4 book chapters). Third, data were analyzed using the *bibliometrics* R package to retrieve statistics on journals, authors, countries, affiliations, and co-citations. Fourth, network analysis was performed to visualize the data using *VOSViewer*. Fifth, we use both *bibliometrics and VOSViewer* to interpret the results through topical analysis.

3 Results

The evolution of this field is captured with descriptive statistics on publications over time, most cited authors, key journals, most cited sources, corresponding author's country and their affiliations. Moreover, co-citation analysis will be used to identify the clusters in this field of research.

3.1 Descriptive Analysis

Over the past 12 years, 822 articles and book chapters were published in innovation and smart city research. Interest in this field started in 2010 with the first publication in this field on learning cities and regions (Longworth & Osborne, 2010). Since 2015, interest in this field started a momentum that continuously accelerated with outputs that peaked in 2021 with 187 publications. Up to the end of March, researchers have published 60 articles and chapters in 2022 (Fig. 1).

Innovation and smart cities research had contributions from 2254 authors. Most of these authors had only one publication, and only 229 authors had more than one output. Table 1 lists the most cited authors in this field in descending order of total citations (TS), number of publications (NB), and *h*-index. Michael Batty leads with number of citations, whereas Tan Yigitcanlar leads with number of publications. Alberto Ferraris comes second with 606 citations and 9 publications, followed by Mark Deakin with 561 citations and 8 publications.

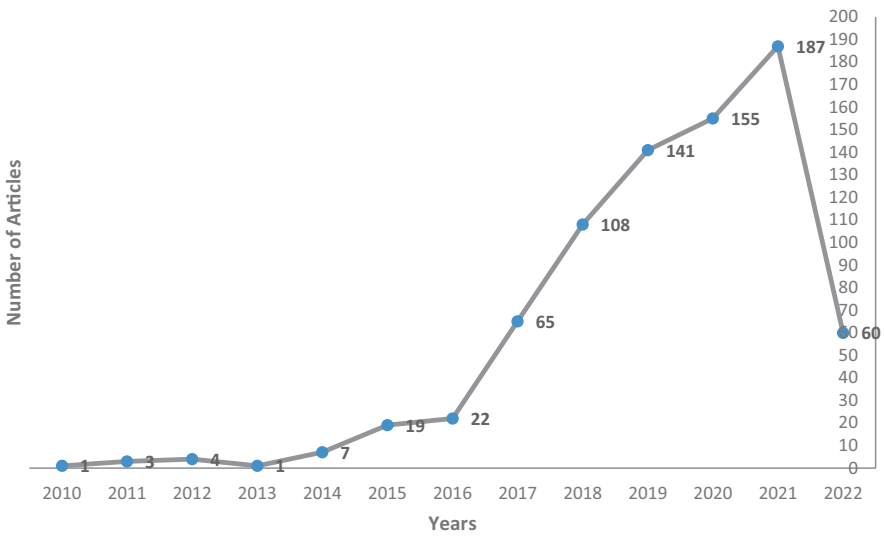

Fig. 1 Publications over time (2010–2022) in WoS

Table 1 Most cited authors

#	Authors	NP	TC	*h*-index
1	Michael Batty	4	863	3
2	Alberto Ferraris	9	606	9
3	Mark Deakin	8	561	7
4	Margarita Angelidou	5	560	5
5	Stefano Bresciani	6	521	6
6	Tan Yigitcanlar	13	478	9
7	Luca Mora	9	380	7
8	Rob Kitchin	6	359	6
9	Jamile Sabatini-Marques	5	254	4
10	Alasdair Reid	6	209	5
11	Igor Calzada	6	178	5
12	Anastasia Panori	6	146	5
13	Luis Carvalho	4	125	3
14	Christina Kakderi	6	72	5
15	Yuanping Wang	5	65	2
16	Yajing Zhang	8	64	3
17	Nathalie Crutzen	4	52	3
18	Stan Geertman	4	51	3
19	Mário Franco	8	39	3
20	Margarida Rodrigues	8	39	3

NP: total number of publications; TC: total citations; *h*-Index: calculated based on author contributions to this area. Authors listed in descending order of TC

Articles have been published in several journal outlets. Journals with the most publications are *Sustainability* (88 articles), *Technological Forecasting and Social Change* (37 articles), and *Cities* (27 articles). The top 20 journals are listed in Table 2 with the total number of articles (NP), total citations (TC), and average citation scores (TC/NP). *Technological Forecasting and Social Change* has the highest score (46.81), followed by *Cities* (44.52) and *Government Information Quarterly* (40.00).

Total number of citations (TC) can be used as a measure of the impact of an article. Moreover, the yearly number of citations (TC/Y) score shows the yearly relevance of an article since it was published. Table 3 lists the 10 most cited sources in this field of research. The most cited article is Batty et al. (2012a, b), with 826 citations and a yearly citation score of 75.09. In this key contribution, Batty et al. defined smart cities, outlined research challenges, and outlined the paradigm shift from older to smarter cities. The second most cited article is Lombardi et al. (2012), with 381 citations. Lombardi et al. modeled smart city performance using the triple helix model and analytic network process. Their results indicate four categories of smart cities: entrepreneurial, pioneer, liveable, and connected cities. Lee et al. (2014) is the third most cited article with 333 citations. They developed a framework for smart city analysis with dimensions and subdimensions to help implement new smart cities and learn from Seoul and San Francisco. The fourth most cited article is

Table 2 List of journals

#	Journals	NP	%	TC	TC/NP
1	*Technological Forecasting and Social Change*	37	4.5	1732	46.81
2	*Cities*	27	3.28	1202	44.52
3	*Government Information Quarterly*	9	1.09	360	40.00
4	*Journal of Urban Technology*	22	2.68	843	38.32
5	*Journal of Cleaner Production*	16	1.95	513	32.06
6	*Urban Studies*	7	0.85	159	22.71
7	*Journal of Science and Technology Policy Management*	6	0.73	125	20.83
8	*European Planning Studies*	7	0.85	129	18.43
9	*Sustainable Cities and Society*	18	2.19	314	17.44
10	*Sensors*	16	1.95	205	12.81
11	*Sustainability*	88	10.71	907	10.31
12	*IEEE Access*	16	1.95	146	9.13
13	*Energies*	17	2.07	136	8.00
14	*International Entrepreneurship and Management Journal*	6	0.73	40	6.67
15	*Technology Innovation Management Review*	7	0.85	36	5.14
16	*Smart Cities*	16	1.95	75	4.69
17	*International Journal of E-Planning Research*	7	0.85	27	3.86
18	*IEEE Transactions on Engineering Management*	5	0.61	18	3.60
19	*Regional Studies*	6	0.73	19	3.17
20	*Wireless Personal Communications*	6	0.73	5	0.83

NP: total number of publications; %: percentage of publications in the dataset of 822 publications; TC: the total citations of a journal; TC/NP: average number of overall citations per article of a journal

Angelidou (2015), with 310 citations. Angelidou outlined the four forces shaping smart cities, including urban futures, knowledge and innovation economy, technology push, and application pull. Although Yang et al. (2017) is the fifth most cited article, it has one of the second highest yearly number of citations score (47.50). Yang et al. (2017) explored the technologies and solutions addressing big data challenges. Another article with a high yearly number of citations score is Cardullo and Kitchin (2019). They framed "citizen-centric" smart cities by rethinking "smart citizens" and "smart citizenship".

The ten most productive universities are listed in Table 4. Queensland University of Technology leads with 28 publications, followed by Edinburgh Napier University with 25 publications, then the University of Beira Interior with 24 publications. Aristotle University Thessaloniki and University Turin have 22 publications.

Authors from 76 countries published articles and chapters in this field of research. Table 5 lists the top 20 countries with the most publications. China leads with 94 publications, followed by the United Kingdom with 88 publications, then Italy with 83 publications. China's national development strategy and the 13th Five-Year Plan (2016–2020) include smart cities (Atha et al., 2020). Korea leads with an average citation score of 60.40 with only 15 publications, followed by Ireland (37.45) with only 11 publications and Greece (33.83) with 23 publications.

Table 3 The most cited sources

#	Authors	Year	Title	Journal	TC	TC/Y
1	Batty M, Axhausen KW, Giannotti F, Pozdnoukhov A, Bazzani A, Wachowicz M, Ouzounis G, and Portugali Y.	2012	Smart cities of the future	*The European Physical Journal Special Topics*	826	75.09
2	Lombardi P, Giordano S, Farouh H, and Yousef W.	2012	Modeling the smart city performance	*Innovation: The European Journal of Social Science Research*	381	34.64
3	Lee JH, Hancock MG, and Hu MC.	2014	Toward an effective framework for building smart cities: Lessons from Seoul and San Francisco	*Technological Forecasting and Social Change*	333	37.00
4	Angelidou M.	2015	Smart cities: A conjuncture of four forces	*Cities*	310	38.75
5	Yang C, Huang Q, Li Z, Liu K, and Hu F.	2017	Big Data and cloud computing: innovation opportunities and challenges	*International Journal of Digital Earth*	285	47.50
6	Gretzel U, Werthner H, Koo C, and Lamsfus C.	2015	Conceptual foundations for understanding smart tourism ecosystems	*Computers in Human Behavior*	252	31.50
7	Mora L, Bolici R, and Deakin M.	2017	The first two decades of smart-city research: A bibliometric analysis	*Journal of Urban Technology*	194	32.33
8	Cardullo P, and Kitchin R.	2019	Being a "citizen" in the smart city: Up and down the scaffold of smart citizen participation in Dublin, Ireland	*GeoJournal*	168	42.00
9	Leydesdorff L, and Deakin M.	2011	The triple-helix model of smart cities: A neo-evolutionary perspective	*Journal of Urban Technology*	166	13.83
10	Yigitcanlar T, Kamruzzaman M, Buys L, Ioppolo G, Sabatini-Marques J, da Costa EM, and Yun JJ.	2018	Understanding "smart cities": Intertwining development drivers with desired outcomes in a multidimensional framework	*Cities*	165	33.00

TC: the total citations per source; TC/Y: yearly number of citations

3.2 Co-citation Analysis

Co-citation analysis helps identify the most relevant and impactful sources based on their citations. In addition, it is useful in detecting schools of thought, as it maps articles cited by identified samples (Aria & Cuccurullo, 2017). A co-citation

Table 4 The most productive universities

#	Affiliations	Country	NP
1	Queensland University of Technology	Australia	28
2	Edinburgh Napier University	The United Kingdom	25
3	University of Beira Interior	Portugal	24
4	Aristotle University Thessaloniki	Greece	22
5	University Turin	Italy	22
6	Utrecht University	Netherlands	21
7	Open University	The United Kingdom	19
8	Oxford University	The United Kingdom	19
9	Delft University of Technology	Netherlands	18
10	Erasmus University	Netherlands	18

Table 5 Corresponding author country

#	Country	NP	%	TC	TC/NP
1	China	94	11.44	759	8.07
2	The United Kingdom	88	10.71	2401	27.28
3	Italy	83	10.10	2188	26.36
4	Spain	54	6.57	1008	18.67
5	The United States	52	6.33	1251	24.06
6	Netherlands	35	4.26	1032	29.49
7	Australia	29	3.53	729	25.14
8	Brazil	29	3.53	238	8.21
9	Portugal	25	3.04	146	5.84
10	Greece	23	2.80	778	33.83
11	Sweden	18	2.19	336	18.67
12	India	18	2.19	253	14.06
13	Finland	17	2.07	172	10.12
14	Korea	15	1.82	906	60.40
15	Canada	15	1.82	147	9.80
16	France	14	1.70	189	13.50
17	Norway	12	1.46	204	17.00
18	Ireland	11	1.34	412	37.45
19	Belgium	10	1.22	163	16.30
20	Denmark	9	1.09	141	15.67

NP: total number of publications; %: percentage of publications in the dataset of 822 publications; TC: total citations per country; TC/NP: average number of overall citations per country

analysis was performed using the Louvain clustering algorithm (Blondel et al., 2008) generating the co-citation network. This network can be visualized using VOSViewer, as illustrated in Fig. 2. Innovation in smart city research contains four clusters (Table 6): open innovation (in red), urban innovation (in green), sustainable innovation (in blue), and digital innovation (in yellow).

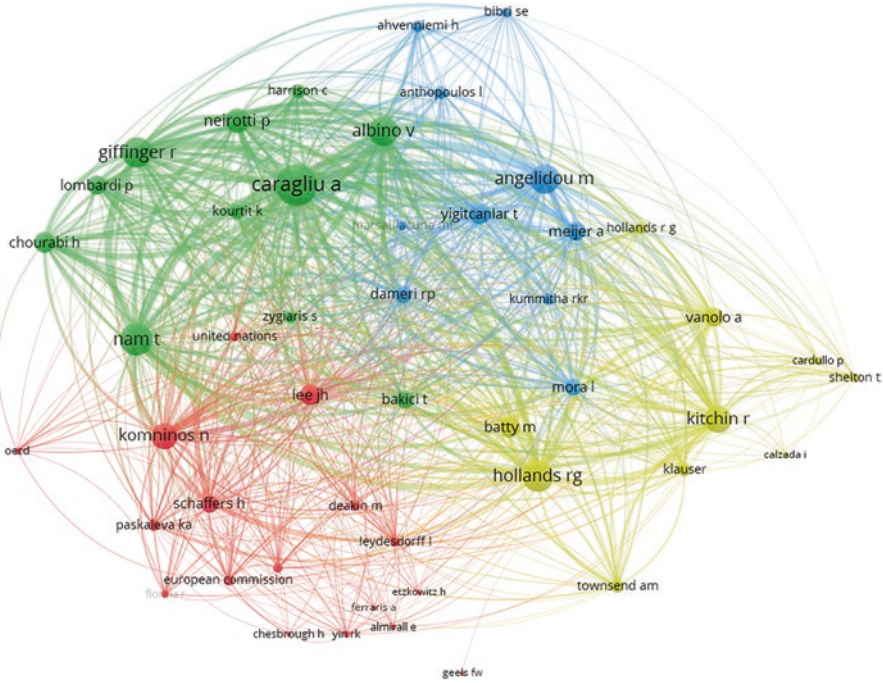

Fig. 2 Co-citation network among authors

Table 6 Major clusters in SSC research

Cluster	Research foci	Studies
Cluster 1	Open Innovation	Etzkowitz and Leydesdorff (2000); Geels (2002); Chesbrough (2003); Leydesdorff and Deakin (2011); Paskaleva (2011); Schaffers et al. (2011); Almirall et al. (2016); Cohen et al. (2016); Ferraris et al. (2020)
Cluster 2	Urban Innovation	Giffinger and Haindlmaier (2010); Harrison et al. (2010); Nam and Pardo (2011); Chourabi et al. (2012); Kourtit and Nijkamp (2012); Lombardi et al. (2012); Bakıcı et al. (2013); Zygiaris (2013); Neirotti et al. (2014); Albino et al. (2015); Caragliu and Del Bo (2019)
Cluster 3	Sustainble Innovation	Dameri (2013); Yigitcanlar and Lee (2014); Angelidou (2015); Marsal-Llacuna et al. (2015); Meijer and Bolívar (2016); Ahvenniemi et al. (2017); Anthopoulos (2017); Bibri and Krogstie (2017); Kummitha and Crutzen (2017); Mora et al. (2017); Yigitcanlar et al. (2019)
Cluster 4	Digital Innovation	Hollands (2008); Batty et al. (2012a, b); Townsend (2013); Kitchin (2014); Vanolo (2014); Calzada and Cobo (2015); Shelton et al. (2015); Cardullo and Kitchin (2019); Söderström et al. (2020)

4 Discussion

We performed two sets of analyses: descriptive and co-citation. The former indicates that interest in this field of research is increasing, and substantial contributions have been made in the past 12 years, with 822 articles and book chapters. The most cited authors include Michael Batty, Alberto Ferraris, and Mark Deakin. Tan Yigitcanlar leads with most published articles and book chapters. Research has been published in leading journals such as *Technological Forecasting and Social Change, Cities, Government Information Quarterly, Journal of Urban Technology,* and *Journal of Cleaner Production*. The most cited articles include Batty et al. (2012a, b), Lombardi et al. (2012), and Lee et al. (2014). In addition, the most productive universities in this field of research are Queensland University of Technology, Edinburgh Napier University, and University of Beira Interior. While China, the United Kingdom, and Italy lead in terms of the number of publications in this field, Korea, Ireland, and Greece lead with average citation scores. The latter analysis generated the co-citation network with four clusters: open, urban, sustainable, and digital innovation.

Cluster 1. Open Innovation
This cluster brings together research focusing on open innovation using the triple helix model (Etzkowitz & Leydesdorff, 2000), technological transitions (Geels, 2002), and open innovation (Chesbrough, 2003). First, advocates of the triple helix model suggest that instead of focusing on the national systems of innovation, institutional transformations can be achieved by rearranging university–industry–government relations (Etzkowitz & Leydesdorff, 2000). Using the triple helix model, Leydesdorff and Deakin (2011) argue that "cities can be considered as densities in networks among three relevant dynamics: the intellectual capital of universities, the wealth creation of industries, and the democratic government of civil society" (p. 53). They draw this argument from the experiences of cities such as Montreal and Edinburgh and demonstrate the transition of these cities to become "smarter" cities. Moreover, Ferraris et al. (2020) delved into the role of universities in smart city innovation, arguing that this can be achieved through multiple roles played by universities, such as a source of knowledge and financial mediator and an engager of different city stakeholders. Second, Geels (2002) argues that technological transitions not only involve technological changes but also affect regulations, infrastructure, industrial networks, practices, and culture. In city transformation, Almirall et al. (2016) discussed three tensions, namely, governance models—role as an orchestrator of ecosystems, as well as a collaborator, growth—maintaining as well as supporting new structures for innovation, and the sharing economy—resolving conflicts between two modes of production. Third, influenced by the work of Chesbrough (2003), several studies have emerged. Paskaleva (2011) probed European Union (EU) programs and found that an open innovation approach has emerged through linking urban territories, people, technologies, and other cities. She argues that this approach can be effective and sustainable as long as consistent frameworks, principles, and agendas are implemented. Schaffers et al. (2011)

looked at how the future of the Internet in smart cities can be explored although an open and user-driven innovation environment that enables experimentation in the domain of living labs. Finally, Cohen et al. (2017) explored the role of cities as a driver for open innovation and entrepreneurship. They argue that cities are becoming living labs for solving complex societal challenges through rapid prototyping and testing of innovations.

Cluster 2. Urban Innovation

Smart cities have become a cornerstone in urban planning (Kourtit & Nijkamp, 2012). Harrison et al. (2010) suggest that urban innovation can be achieved by using information technology (IT) to exploit existing data on traffic, energy, and citizen habits. They suggest that this could be achieved through instrumented, interconnected, and intelligent operations. While instrumental relates to real-time data, interconnected relates to the integration of data into one platform, and intelligent relates to modeling, optimization, and visualization of operations. To showcase urban innovation, studies have examined the performance of smart cities. Giffinger et al. (2010) have looked at the dimensions and subdimensions of ranking smart cities, including smart economy, smart people, smart governance, smart mobility, smart environment, and smart living. Using the triple helix model, Lombardi et al. (2012) looked at the different dimensions used to measure smart city performance in relation to university, civil society, and industry by listing subdimensions of smart governance, smart economy, smart human, smart living, and smart environment. By examining different performance measures of smart city initiatives, Albino et al. (2015) show the complexity of measuring smart city performance. Using the case of Barcelona, Zygiaris (2013) and Bakıcı et al. (2013) show how to build smart cities within an innovative ecosystem. Zygiaris (2013) introduced the Smart City Reference Model, which includes seven city planning layers: the city, green city, interconnection, instrumentation, open integration, application, and innovation layers. To implement innovation in smart cities, city planners need to comprehend the factors facilitating execution. These factors include technological, institutional, and human factors (Nam & Pardo, 2011) and IT infrastructure, security and privacy, and operational costs (Chourabi et al., 2012). The impact of smart city initiatives has been measured using total patent applications (Caragliu & Del Bo, 2019) and acceptance and use (Neirotti et al., 2014).

Cluster 3. Sustainable Innovation

A smart and sustainable city is "an innovative city that uses information and communication technologies (ICT) and other means to improve quality of life, efficiency of urban operation and services, and competitiveness, while ensuring that it meets the needs of present and future generations, with respect to economic, social and environmental aspects" (ITU, 2014). Before cities become smart, they need to be sustainable (Ahvenniemi et al., 2017; Yigitcanlar et al., 2019). Yigitcanlar et al. (2019) claim that three challenges face sustainable innovation in smart cities: technocentricity, practice complexities, and ad hoc notions of smart cities. Ahvenniemi et al. (2017) distinguished between the use of two terms "smart cities" and

"sustainable cities" and suggested the use of a more accurate term "smart sustainable cities". The aim of smart and sustainable cities is "to maximize efficiency of energy and material resources, create a zero–waste system, support renewable energy production and consumption, promote carbon–neutrality and reduce pollution, decrease transport needs and encourage walking and cycling, provide efficient and sustainable transport, preserve ecosystems, emphasize design scalability and spatial proximity, and promote livability and sustainable community" (Bibri & Krogstie, 2017, p. 193). By examining ten smart city cases, Anthopoulos (2017) shows different aspects of sustainability for different smart cities. Smart and sustainable cities have been shown to create economic and public value (Dameri & Rosenthal-Sabroux, 2014).

Cluster 4. Digital Innovation

The quest for a new utopia for cities can be achieved through ubiquitous computing in urbanism (Townsend, 2013). On the one hand, and in their seminal piece, Batty et al. (2012a, b) worked on the *FutureICT* program that introduced an innovative approach to technological innovation. This approach advocates that technology is a social construction involving hardware, software, databases, and organizational technologies. They argue that the use of technological innovations can help city planners sense and measure, exchange in urban markets, and model. Moreover, digital innovation produces big data, enabling real-time city life analysis, novel approaches to city governance, and providing more efficient, productive, transparent, open, and sustainable cities (Kitchin, 2014). On the other hand, smart city agendas are driven by large IT corporations such as IBM (Söderström, 2014; Shelton et al., 2015). Calzada and Cobo (2015) criticize technological determinism and propose the ten dimensions of social innovation in smart cities. They argue that unplugging could be beneficial, and these benefits should not be disregarded because of the abundance of digital innovations. Moreover, Hollands (2008) argues that the smart city agenda assumes a positive impact of digital technologies with a hidden policy agenda of "high-tech urban entrepreneurialism". Other studies claim that smart cities enact hidden neoliberal agendas (Shelton et al., 2015; Cardullo & Kitchin, 2019). The techno-centric vision of smart cities in Europe comes from the availability of financial resources to reconstruct cities, involvement of large private corporations in digitization projects, creation of techno-centric solution-based rhetoric, and focus on sustainable smart cities to resolve economic crises (Vanolo, 2014).

5 Conclusions

The aim of this review chapter is to map existing evidence on innovation and smart city research. Using the ISI WOS database, we retrieved 822 articles and chapters. Bibliometric analyses were used to highlight descriptive statistics and key themes. The evolution of this field of research is captured through descriptive statistics on publications over time, most cited authors, key journals, most cited sources,

corresponding author's country, and their affiliations. Co-citation analysis was used to identify the key themes in this field of research. Four clusters have been identified: open innovation, urban innovation, sustainable innovation, and digital innovation. Although existing evidence suggests that substantial research has been carried out to demonstrate innovation in smart cities, research gaps still exist, and we call for future research to document the innovation journey of smart cities.

6 Future Research

Reviewing existing work in innovation and smart city research, several promising avenues for future research have been highlighted in relation to the four clusters identified earlier. The key research questions are detailed in Table 7.

Although much work has focused on the four clusters, there remain many gaps that could be filled with future research. In the open innovation cluster, future research could exist, and future tensions and what open innovation mechanisms could be employed to resolve these tensions. Moving beyond the triple helix model, what theories can be used to enact open innovation within smart cities? We suggest using dynamic capabilities theory (Teece et al., 1997) to show the different capabilities achieved through open innovation in smart cities. In addition, more work is needed to show the experience of smart cities in using experimentation and rapid prototyping as open innovation methods. Urban innovation is the most

Table 7 Future research on smart city innovation

Cluster	Research questions
1. Open innovation	What are the existing and future tensions of innovation in smart cities? What open innovation methods and approaches will resolve these tensions? What theories can be used to move beyond the Triple Helix model in smart city innovation? How have cities used experimentation and rapid prototyping?
2. Urban innovation	What dimensions, layers, and types of urban innovation? What tools and frameworks can facilitate the implementation of urban innovation in smart cities? What internal and external forces influence urban innovation? What is the impact of urban innovation? How to measure it?
3. Sustainable innovation	What are the different aspects of sustainable innovation? How could city planners embed sustainable innovation in building smart cities? What policies are needed for implementing sustainable smart cities? How to measure the value of sustainable innovation in smart cities?
4. Digital innovation	What are the benefits and/or risks of digital innovations in smart cities? What methods and/or tools can help achieve the optimal balance between benefits and risks of digital innovations in smart cities? Why do digital innovations in smart cities fail and/or succeed? What policy agendas are driving and/or hindering digital innovations in smart cities?

promising research cluster. The UNDP (2021) suggests four types of innovations: community-organized, frugal, enterprise ventures, and institutional pioneers. More work is needed to unravel the dimensions, layers, and types of urban innovation. Furthermore, future research could look at the tools and frameworks that could facilitate the successful implementation of urban innovation in smart cities. Additionally, researchers need to examine the internal and external forces influencing urban innovation and measure the impact and outcomes of such innovations. In the sustainable innovation cluster, researchers can identify the different aspects of sustainable innovation. As cities cannot be smart without being sustainable, it is critical to explore the different ways of embedding sustainable innovation in smart city planning, construction, management and operations, and support. Another critical issue is demonstrating the value of sustainable innovation in smart cities, for which limited research exists. In the digital innovation cluster, researchers could assess the benefits and/or risks of digital innovations. Future research should also focus on methods and/or tools that can help achieve the optimal balance between the benefits and risks of digital innovations. Limited research exists on the success and failure of digital innovation in smart cities. Learning lessons are needed to replicate these innovations in different contexts. Moreover, research should examine existing policies driving and/or hindering digital innovations in smart cities. Finally, researchers need to identify other innovations in smart cities to move away from the holistic perspective of smart cities.

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