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Investigating the entrepreneurial perspective in smart city studies

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Abstract

Although the concept of smart cities has been largely discussed in the literature for over almost three decades, there is still a need to better understand the entrepreneurial aspects surrounding smart cities. This study aims to explore the evolutionary trends of research in the field of Smart Cities, and specifically, to unveil the entrepreneurial aspects prevailing in the literature. With the support of bibliometric analysis and social network analysis tools this paper identifies the foundations and most active areas on smart cities research over the past 20 years. It also scrutinizes and highlights the entrepreneurial aspects prevailing in the smart cities body of knowledge. It provides a critique of the current state-of–the-art of entrepreneurial research in the smart cities future research directions by analyzing the collaboration among the authors and the relation between the knowledge creation and the impact of its results.

Keywords Smart cities · Entrepreneurship · Bibliometric analysis · Social network analysis

Introduction

The widespread availability of digital ecosystems has supported the emergence of different forms of smart solutions addressing urban and environmental challenges. The development

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of smart cities consists in the creation or improvement of citizen services by leveraging the affordances of digital ecosystems (Cocchia 2014; Neirotti et al. 2014; Meijer and Bolívar 2016; Hollands 2008). As a result, smart cities create a revised vision of the city's role in the economic and social context and a pervasive use of technological innovations, particularly digital tools that facilitate interconnection of different stakeholders.

In this context, one of the key aspects of smart city initiatives is the development of an entrepreneurial ecosystem. The Tel Aviv[1] smart city model provides a good example as it focused on strong entrepreneurial aspects and has several significant strengths for exploiting business opportunities for creative industries in the city. Another example of successful smart city development is the case of Santander.[2] From an urban development perspective, the city of Santander focused on the consolidation of the fabric of local businesses, the improvement in the quality of residents' life, the reduction of urban services costs and the positioning of the city as a world leader in the field of innovation.

According to Bresciani et al. (2017), smart cities facilitate the connection among the physical, IT, social and business infrastructures in order to leverage the intelligence of the city's community. For this reason, cities are playing a relevant role to drive innovation of firms in a wide variety of industries such as health, environment, and information and communication technology, among others (Zanella et al. 2014; Scuotto et al. 2016). In addition, smart cities can contribute to economic and social development and the design of organizational systems that use technology to provide sustainable, personal and interactive services (Anttiroiko 2015; Silva et al. 2018). In particular, firms may exploit cooperation networks with various partners and city stakeholders by using the data generated by the Internet of Things (IoT). This allows to provide a number of benefits in the management and optimization of traditional public services and to stimulate the active participation of citizens in the public administration management (Zanella et al. 2014; Bresciani et al. 2018).

Although the concept of smart cities has been largely discussed in the literature for over almost three decades (Appio et al. 2019; Mora et al. 2017; Neirotti et al. 2014; Schiavone et al. 2019), this research area is still unable to clearly pinpoint what are the entrepreneurial conditions enabling the development of smart cities (Leydesdorff and Deakin 2011; Kraus et al. 2015; Mora et al. 2017; Komninos and Mora 2018). Several scholars underlined the need of classifying the research area based on the main trends and to systematizing, categorizing and ordering the research on this field (Adriaanse and Rensleigh 2013; Bjork et al. 2014; Liñán and Fayolle 2015).

In the light of these emerging changes and the need to better investigate these aspects, our study aims to show the evolutionary trends of research in the field of Smart Cities, and specifically, to unveil the entrepreneurial aspects prevailing in the literature (Autio 2017; Ramoglou and Tsang 2016; Fitz-Koch et al. 2018; Terjesen et al. 2016; Mainela et al. 2014). In particular, this would help to identify not only the main themes in the literature, but also the existing gaps and new relevant lines of research related to the entrepreneurial aspects of smart cities. Through our exploratory analysis, we aim at contributing to the entrepreneurship literature as follows:

[1] IDB, June 2016, International Case Studies of Smart Cities. Tel Aviv, Israel. Available at: file:///C:/Users/Hp/Downloads/International-Case-Studies-of-Smart-Cities-Tel-Aviv-Israel.pdf

[2] IDB, June 2016, International Case Studies of Smart Cities. Santander, Spain. Available at: file:///C:/Users/Hp/Downloads/International-Case-Studies-of-Smart-Cities-Santander-Spain%20(1).pdf

- providing a descriptive analysis on the past scientific contributions debating smart cities, by integrating other bibliometric works such as Mora et al. (2017), covering also the period after 2012;
- investigate the collaboration among the authors, the relation between the knowledge creation process of the specific research community and the impact of its research results;
- scrutinize and highlights the entrepreneurial aspects prevailing in the literature

The paper unfolds as follows. The research methodology and the literature search protocol are described in the second section. The results of the analysis are provided in the third section. Finally, fourth section concludes the paper summarizing findings, limitations and future steps.

Research framework and data collection

Considering our aim to investigate the literature discussing smart cities and in order to identify foundations and most active research areas we make use of citation analysis. Citation analysis is a form of quantitative bibliography which uses quantitative measures of number of publications and number of citations and co-citation as proxies of the influence of various sources in a research discourse (Culnan 1986; Pritchard 1969). Citation analysis allows to investigate the evolution of knowledge production in a specific context (i.e. a discipline, a research area, a journal, a group of authors) (Laine 2009; Polites and Watson 2009). It allows to picture the intellectual nature of such context (Garfield 1979), and may be used to map the evolution which happens through the rise and fall of paradigms (Kuhn 1962). Co-citation analysis is a form of citation analysis which provides a method for assessing the cumulative tradition of a specific context (Culnan 1986; Hamilton and Ives 1980, 1982). This analysis allows identifying papers considered as highly relevant for a discourse in the literature. Sources cited more frequently together tend to cluster (Small 1993) and through the analysis of these clusters the foundations of a literature discourse can be identified (Za et al. 2020). Since citation analysis alone does not show the structure of ideas in a field (Bernroider et al. 2013), like previous studies did (Polites and Watson 2009), we used social network analysis tools to obtain citation based measures of literature sources.

For bibliometric studies that involve citation/co-citation analysis literature selection is a key aspect to ensure validity and consistency. To perform the literature selection and the eventual analysis of the results we followed a sequential research protocol composed by five steps illustrated in Fig. 1.

The first step concerns the data collection and involves the identification of a suitable source for literature search. We use Scopus database since it fully covers over 20.000 major journals adding up around 70 million searchable records. In this way we have the possibilities to examine a broader collection of articles containing “Smart City” (captured in singular and plural forms) focusing only to journal articles published in English language. We obtained a dataset composed by 3553 papers, where more than 2200 were published in the last 2 years. This element underlines the need to have an updated literature analysis, since the recent broad literature reviews, such as Mora et al. (2017), do not consider contributions published in the last years. Before to perform the

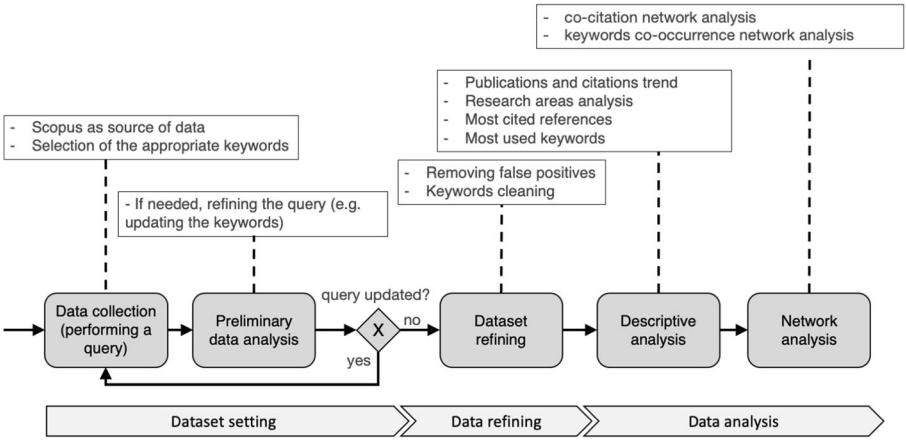

Fig. 1 Research protocol (adapted from Za and Braccini 2017)

data analysis we refined the dataset working on the keywords used by the authors in their contributions. We replaced all the authors' keywords indicating the same topic with a unique one. The Table 1 shows the adaptation regarding the most recurring keywords (e.g. all the "smart cit*" occurrences were replaced with "smart city").

In order to explore the entrepreneurial perspective in smart city studies, we focused on a restricted dataset built using a second query in which we combined "smart cit*" and "entrepreneur*" keywords.

The second query produces 104 records. We then performed a preliminary analysis (data refining phase) in order to identify and delete possible wrong selections. The resulting dataset was composed by 53 papers discussing entrepreneurial issues in the smart city context.

For both datasets, we carried out a bibliometric descriptive analysis, specifically considering number of publications and number of citations and co-citations (López-Fernández et al. 2016; Zupic and Čater 2015). Moreover, in order to investigate the topics debated in the

Table 1 The refined set of the most occurrence keywords

Original authors' keywords	The adopted keywords
Smart cities Smart city	Smart city
Internet of Things Internet of Things (Iot) IoT	Internet of Things
Cloud computing Cloud	Cloud computing
Wireless sensor network Wireless sensor networks	Wireless sensor networks
Intelligent transportation system Intelligent transportation systems	Intelligent transportation systems
Sensor Sensors	Sensors

corpus, we perform thematic analysis (Liñán and Fayolle 2015) considering keywords defined by the authors of each contribution and their relations using SNA tools. The use of SNA for literature analysis, especially within the social sciences (Chabowski et al. 2013; Vogel 2012) such as management, entrepreneurship and innovation (Baier-Fuentes et al. 2018), allows to examine the behavior of a scientific community (recognizing in same cases more than one community) based on the data of the related publications, discovering some links among the objects of analysis (Za et al. 2020, Ricciardi and Za 2015).

On both datasets, following the further steps of the research protocol, we carried out both descriptive and a network analysis. Moreover, since the second dataset is composed only by 53 papers, we were able to deeply review each paper in order to analyze how the authors debate the entrepreneurial issues in smart city context. This analysis gave us the possibility to identify a set of clusters based on how and what issues are addressed in each contribution.

Results

Our analysis indicates that smart city research has represented a new area of scientific enquiry starting around 10 years ago, and since then, it has been fast-growing, arousing strong interest from an expanding scientific community of researchers (Mora et al. 2017). This evolution is confirmed by observing the trend in the production of source documents (Fig. 2), which has continued to increase over time, together with the number of scholars (Fig. 3).

Bibliometric analysis on smart cities

This section reports the main findings of the bibliometric analysis that was applied to records that are associated with smart cities research and published between 1997 and 2019. This analysis was conducted in January 2019 and achieved 3553 publications

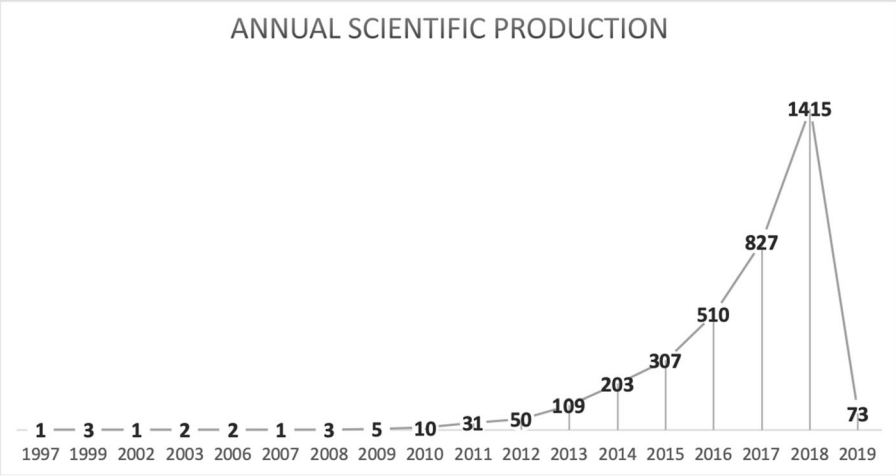

Fig. 2 Number of publications per year in Smart Cities research since 1997

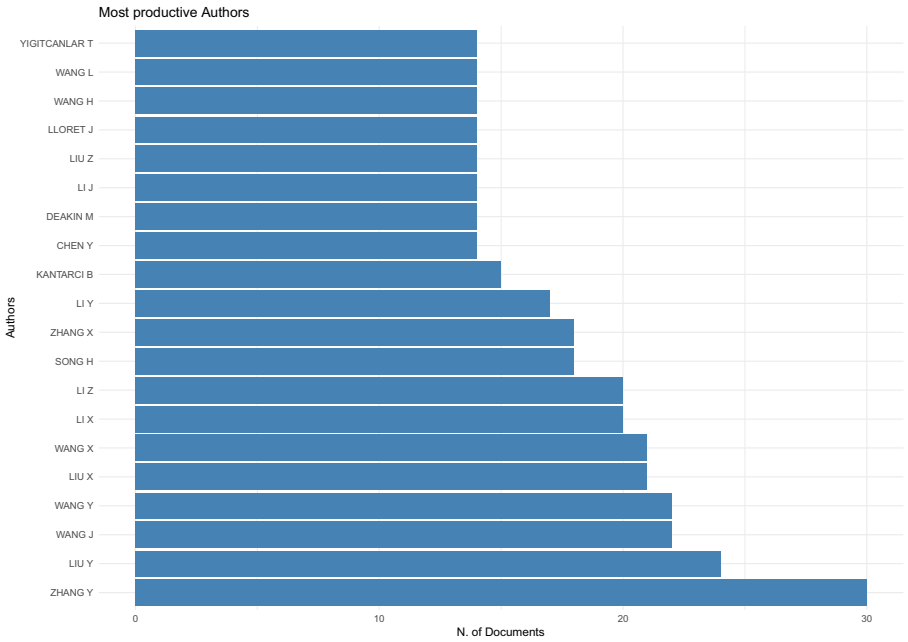

Fig. 3 Most productive authors

derived from 968 different sources (Journals, Books, etc.) with an average citation for each publication of 9.6.

According to the Fig. 2, smart cities research has significantly increased in recent years since most of the papers have been published in the last decade; the most productive year was the 2018 with 1415 papers representing almost the 40% of the total publications in the dataset. Furthermore, if we consider the period between 2013 and 2019, we cover the 96.9% of the total volume.

Several factors explain this significant increase in number of publications. One could be the need to investigate smart cities for the emerging widespread availability of digital ecosystems and networking tools fostering the development of smart solutions addressing urban and environmental challenges (Zygiaris 2013). Another one could be the need to investigate management, governance and innovation issues affecting organizations and societies implementing projects and looking for solutions in this context (Almirall et al. 2016). Moreover, this growing interest is confirmed by the number of journal special issues (more than 10 have a submission deadline in the year 2019) on smart city investigating several aspects in different disciplines launched in the recent years (https://www.mdpi.com/journal/smartcities/special_issues).

Studies on smart cities are published among various journals, Table 1 shows the ranking of the 30 most productive journals, from which (looking at the first five journals) it is possible to recognize a main focus on technical issue. According to Table 1, it is notable that the most productive journal in smart cities discipline is the Sensors (Switzerland) with 145 out of 3553 published articles which represent 4.02%, followed by IEEE Access and Future Generation Computer Systems, respectively with 133 and 100 papers published.

A further metric to be considered in this analysis is represented by the most productive authors that are Zhang Y. with 30 contributions, followed by Liu Y., Wang J. and Wang Y. with 24, 22 and 22 articles respectively.

In order to complete the broader overview on the 3553 contributions in the dataset, Fig. 4 shows the most productive countries, considering the affiliation of the authors, where there is a distinction between paper where the authors have the same affiliation country (Single country publication – SCP) and the multi-country configuration (Multiple country publication – MCP). The paper with authors with a multi-country configuration are associated with the country of the corresponding author. On the basis of this analysis, the debate on smart cities is mainly developed in European Union (especially in Italy and Spain) than in US or China.

Moreover, number of citations per country are reported in Table 2. According to the table, Italy is the most influential and productive country with 225 papers that have been published. In addition, Italy has received 4610 citations compared to the second country US that received 2882 (Table 2). Spain and United Kingdom cover the third and fourth place, respectively with 2373 and 2309 citations. However, these metrics are considerably higher compared to the remaining countries.

Many European countries (16 out of 30) appear on this list and five of these countries dominate the top 10 positions. However, in light of previous work of Baier-Fuentes et al. (2018), it is important to show the poor productivity in Latin American countries: only Brazil and Mexico are in the list at 26th and 30th positions (Table 3).

One method to achieve an accurate picture of the documents published in a specific discipline is through the analysis of the number of citations received (Merigó and Yang 2017; Baier-Fuentes et al. 2018). The number of citations shows the popularity and influence

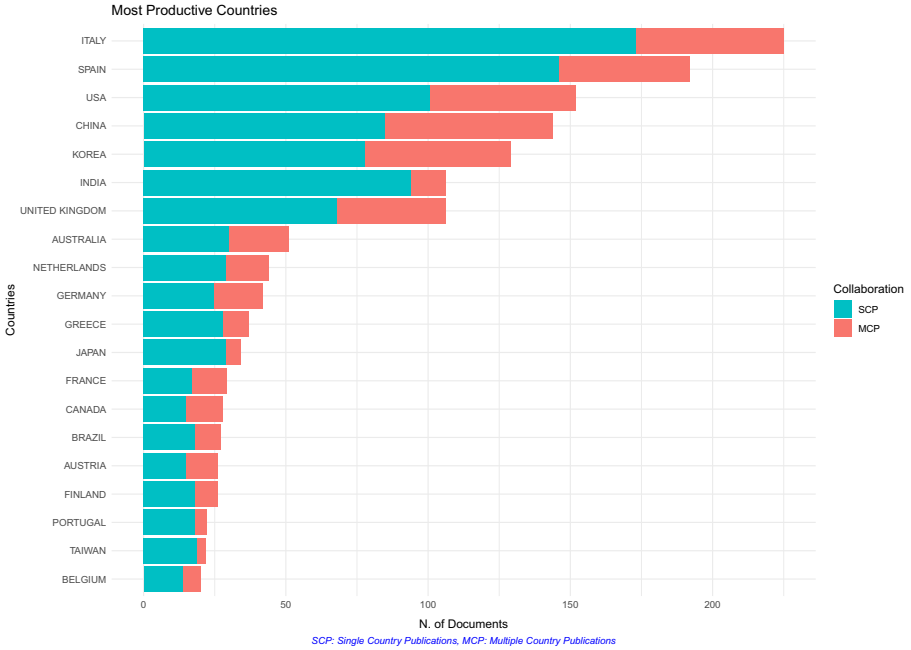

Fig. 4 Most productive countries

Table 2 Most influential journals

Journal	N° papers
1 Sensors (Switzerland)	145
2 IEEE Access	133
3 Future Generation Computer Systems	100
4 IEEE Communications Magazine	83
5 IEEE Internet of Things Journal	69
6 Sustainability (Switzerland)	66
7 Sustainable Cities and Society	63
8 Technological Forecasting and Social Change	54
9 Cities	47
10 IEEE Transactions on Intelligent Transportation Systems	36
11 Journal of Urban Technology	35
12 International Journal of Distributed Sensor Networks	34
13 International Journal of Engineering and Technology (UAE)	31
14 IEEE Sensors Journal	29
15 IEEE Transactions on Industrial Informatics	26
16 Energies	24
17 Techne	23
18 Interaction Design and Architecture(S)	22
19 International Journal of Civil Engineering and Technology	22
20 Journal of Cleaner Production	22
21 Wireless Communications and Mobile Computing	22
22 Wireless Personal Communications	22
23 IEEE Internet Computing	21
24 Computer Networks	20
25 Cluster Computing	18
26 Government Information Quarterly	18
27 Pervasive and Mobile Computing	18
28 Ad Hoc Networks	17
29 IEEE Transactions on Vehicular Technology	17
30 ISPRS International Journal of Geo-Information	17

of the paper in the scientific community. Table 4 presents the 30 most cited articles in the sample.

It is important to note that some of the most cited and influential paper is Zanella et al. (2014), which has 1268 citations. The second cited paper has even half of the citations of the first in the ranking (Hollands 2008). Within the ranking only two papers were published before the 2010 and are Shapiro (2006) and Hollands (2008). Note finally that this list includes any type of publication and not only academic articles because the focus is on the number of citations (Table 4).

Furthermore, in order to explore the most relevant topic discussed in our dataset, we analyse the most occurrence keywords. The analysis of the keywords provides some

Table 3 Total citations and average article citation per country

#	Country	Total citations	Average article citation
1	Italy	4610	20.489
2	Usa	2882	18.961
3	Spain	2373	12.359
4	United Kingdom	2309	21.783
5	Korea	1165	9.031
6	China	860	5.972
7	Greece	771	20.838
8	Australia	766	15.020
9	Ireland	672	35.368
10	Canada	601	21.464
11	Netherlands	580	13.182
12	South Africa	433	43.300
13	Finland	364	14.000
14	France	315	10.862
15	Romania	270	20.769
16	Germany	237	5.643
17	Austria	219	8.423
18	Belgium	218	10.900
19	Sweden	210	11.667
20	Singapore	205	10.789
21	Hong Kong	169	9.389
22	India	161	1.519
23	Japan	141	4.147
24	Switzerland	131	9.357
25	Norway	120	8.000
26	Brazil	114	4.222
27	Cyprus	107	15.286
28	Bahrain	97	97.000
29	Portugal	84	3.818
30	Mexico	83	7.545

insights regarding the content and the main issues on smart cities discussed by the authors of the 3553 contributions.

The keywords analysis provided an overview of research trends, since keywords reflect the focus of individual articles.

We identify the most popular keywords used in the dataset, creating a graph based on their co-occurrences (Fig. 5). In the network, the keywords are the nodes and there is a tie among two of them if mentioned together in the same publication (co-occurrence); the thickness indicates the number of contributions in which the pair appears.

Table 4 Most cited articles on smart cities

#	Article	Cit.
1	Zanella, A., Bui, N., Castellani, A., Vangelista, L., & Zorzi, M. (2014). Internet of things for smart cities. IEEE Internet of Things journal, 1(1), 22–32.	1268
2	Hollands, R. G. (2008). Will the real smart city please stand up? Intelligent, progressive or entrepreneurial?. City, 12(3), 303–320.	681
3	Caragliu, A., Del Bo, C., & Nijkamp, P. (2011). Smart cities in Europe. Journal of urban technology, 18(2), 65–82.	665
4	Kitchin, R. (2014). The real-time city? Big data and smart urbanism. GeoJournal, 79(1), 1–14.	470
5	Botta, A., De Donato, W., Persico, V., & Pescapé, A. (2016). Integration of cloud computing and internet of things: a survey. Future generation computer systems, 56, 684–700.	449
6	Neirotti, P., De Marco, A., Cagliano, A. C., Mangano, G., & Scorrano, F. (2014). Current trends in Smart City initiatives: Some stylised facts. Cities, 38, 25–36.	449
7	Batty, M., Axhausen, K. W., Giannotti, F., Pozdnoukhov, A., Bazzani, A., Wachowicz, M., ... & Portugali, Y. (2012). Smart cities of the future. The European Physical Journal Special Topics, 214(1), 481–518.	422
8	Jin, J., Gubbi, J., Marusic, S., & Palaniswami, M. (2014). An information framework for creating a smart city through internet of things. IEEE Internet of Things journal, 1(2), 112–121.	372
9	Shapiro, J. M. (2006). Smart cities: quality of life, productivity, and the growth effects of human capital. The review of economics and statistics, 88(2), 324–335.	351
10	Perera, C., Zaslavsky, A., Christen, P., & Georgakopoulos, D. (2014). Sensing as a service model for smart cities supported by internet of things. Transactions on Emerging Telecommunications Technologies, 25(1), 81–93.	338
11	Albino, V., Berardi, U., & Dangelico, R. M. (2015). Smart cities: Definitions, dimensions, performance, and initiatives. Journal of urban technology, 22(1), 3–21.	304
12	Mancarella, P. (2014). MES (multi-energy systems): An overview of concepts and evaluation models. Energy, 65, 1–17.	283
13	Hasan, M., Hossain, E., & Niyato, D. (2013). Random access for machine-to-machine communication in LTE-advanced networks: Issues and approaches. IEEE communications Magazine, 51(6), 86–93.	270
14	Harrison, C., Eckman, B., Hamilton, R., Hartswick, P., Kalagnanam, J., Paraszczak, J., & Williams, P. (2010). Foundations for smarter cities. IBM Journal of research and development, 54(4), 1–16.	233
15	Sanchez, L., Muñoz, L., Galache, J. A., Sotres, P., Santana, J. R., Gutierrez, V., ... & Pfisterer, D. (2014). SmartSantander: IoT experimentation over a smart city testbed. Computer Networks, 61, 217–238.	223
16	Vanolo, A. (2014). Smartmentality: The smart city as disciplinary strategy. Urban studies, 51(5), 883–898.	211
17	Batty, M. (2013). Big data, smart cities and city planning. Dialogues in Human Geography, 3(3), 274–279.	201
18	Solanas, A., Patsakis, C., Conti, M., Vlachos, I. S., Ramos, V., Falcone, F., ... & Martinez-Balleste, A. (2014). Smart health: a context-aware health paradigm within smart cities. IEEE Communications Magazine, 52(8), 74–81.	187
19	Vlacheas, P., Giaffreda, R., Stavroulaki, V., Kelaidonis, D., Foteinos, V., Poulios, G., ... & Moessner, K. (2013). Enabling smart cities through a cognitive management framework for the internet of things. IEEE communications magazine, 51(6), 102–111.	179
20	Raza, U., Kulkarni, P., & Sooriyabandara, M. (2017). Low power wide area networks: An overview. IEEE Communications Surveys & Tutorials, 19(2), 855–873.	174
21	Allwinkle, S., & Cruickshank, P. (2011). Creating smart-er cities: An overview. Journal of urban technology, 18(2), 1–16.	173

Table 4 (continued)

#	Article	Cit.
22	Hancke, G., Silva, B., & Hancke Jr., G. (2013). The role of advanced sensing in smart cities. Sensors, 13(1), 393–425.	165
23	Bakici, T., Almirall, E., & Wareham, J. (2013). A smart city initiative: the case of Barcelona. Journal of the knowledge economy, 4(2), 135–148.	163
24	Lombardi, P., Giordano, S., Farouh, H., & Yousef, W. (2012). Modelling the smart city performance. Innovation: The European Journal of Social Science Research, 25(2), 137–149.	160
25	Centenaro, M., Vangelista, L., Zanella, A., & Zorzi, M. (2016). Long-range communications in unlicensed bands: The rising stars in the IoT and smart city scenarios. IEEE Wireless Communications, 23(5), 60–67.	155
26	Lin, J., Yu, W., Zhang, N., Yang, X., Zhang, H., & Zhao, W. (2017). A survey on internet of things: Architecture, enabling technologies, security and privacy, and applications. IEEE Internet of Things Journal, 4(5), 1125–1142.	152
27	Cardone, G., Foschini, L., Bellavista, P., Corradi, A., Borcea, C., Talasila, M., & Curtmola, R. (2013). Fostering participaction in smart cities: a geo-social crowdsensing platform. IEEE Communications Magazine, 51(6), 112–119.	148
28	Söderström, O., Paasche, T., & Klauser, F. (2014). Smart cities as corporate storytelling. City, 18(3), 307–320.	147
29	Lazaroiu, G. C., & Roscia, M. (2012). Definition methodology for the smart cities model. Energy, 47(1), 326–332.	144
30	Lee, J. H., Hancock, M. G., & Hu, M. C. (2014). Towards an effective framework for building smart cities: Lessons from Seoul and San Francisco. Technological Forecasting and Social Change, 89, 80–99.	143

Figure 5 shows the 60 most occurred keywords in the dataset, where "Smart City" is the most used component with 1702 occurrences, followed by Internet of Things with more than 500 occurrences, and "Big data" and "cloud computing" are the other keywords with more than 100 occurrence (180 and 108 respectively). The size of

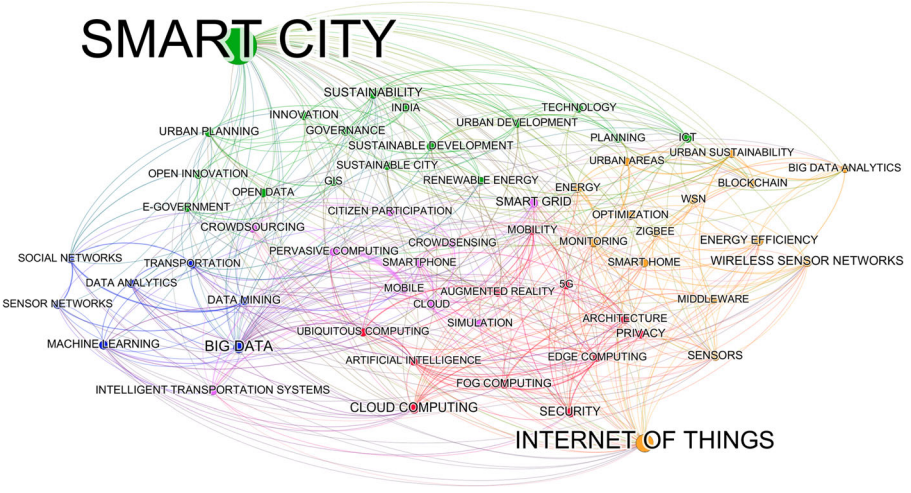

Fig. 5 Keywords co-occurrence graph

each node (and its label) represents the occurrence of keywords within the dataset (how many papers it appears). Overall, analysing the resulting graph, it is possible to recognize five main clusters. The first cluster (the blue one) is more focus on data collection and processing (Big data, data mining and machine learning are the most occurred keywords). The second one (the red one) is focused on the computational infrastructure where cloud, fog and edge computing are the most relevant keywords. The third cluster (the orange one) is related to the IoT related phenomena (where "Internet of Things" is the most occurred keyword). The fourth cluster (the purple one in the centre of the graph) is the related to the pervasive and mobile computing. The last one (the green one) is related to the economic, managerial and social issues concerning smart city, such as sustainability, urban planning, urban development, innovation, governance, etc. Among the most discussed topics, entrepreneur and keywords with the same prefix, have received little attention.

In order to further investigate the topics discussed in the dataset, we elaborate the thematic map, as suggested by (Cobo et al. 2011). The thematic map shows clusters (research themes) of keywords and their interconnections. The clusters are identified by an algorithm taking into consideration the keyword co-occurrence in the dataset. Once the clusters (a collection of keywords) are identified, two parameters are calculated. The "density" is based on the strength of internal ties among all keywords in the same cluster (recognizing the "theme's development"). The "centrality" identifies the strength of the external connections from a cluster to the others (the relevance of the research theme for the specific field of study).

The combination of high and low values for both parameters allows to define a strategic diagram based on four quadrants, distributing the research themes in four groups (Cobo et al. 2011) (Figs. 6 and 7):

– Themes in the upper-right quadrant (1) are the so-called motor-themes of the specialty, are both well established and relevant for the theoretical framework of a research field. Moreover, these themes are related externally to concepts applicable to other themes.

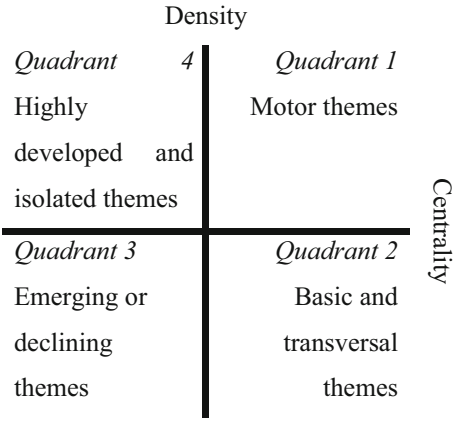

Fig. 6 Strategic diagram adapted by Cobo et al. (2011)

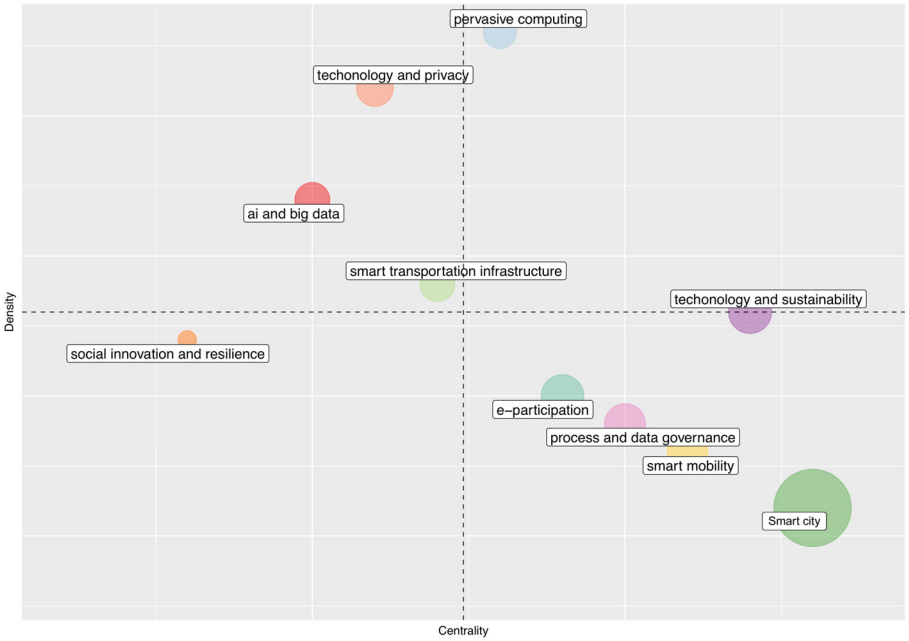

Fig. 7 Thematic map based on the most recurring keywords defined by the authors

- Themes in the upper-left quadrant (2) are considered well developed, specialized but unimportant external ties and so are still of only marginal importance for the field.
- Themes in the lower-left quadrant (3) are considered marginal and weakly established and they can indicate emerging or declining themes.
- Themes in the lower-right quadrant (4) are relevant for specific fields but are still in the process of development. These themes are both basic and transversal.

The thematic map built on the current dataset shows cluster mainly in the second and forth quadrants.

Specifically, "smart city", "smart mobility", "process and data governance" and "e-participation" are the cluster recognized as the motor themes. "Technology and sustainability" could be considered as the main motor theme. This is quite in line with the general concept of smart city, where technologies are used in order to create sustainable and livable city (Chourabi et al. 2012). The presence in the same quadrant of the cluster "pervasive computing" could be also reasonable. Considering the concept of ubiquitous digital ecosystem (Carillo et al. 2017), data are continuously collected and processed through a wide and distributed set of heterogenous smart devices, in order to monitor the environment and provide even more accurate services to the citizens (Chourabi et al. 2012). "smart transportation infrastructure", "AI and Big Data" and "Technology and privacy" represent the highly developed and isolated themes. They could be

considered as three different main themes that could correspond to three different sub communities of scholars discussing very specialized topics connected in some way with smart city issues. The cluster "social innovation and resilience" could be considered as an emerging theme than a declining, since contributions concerning this specific cluster are published only after 2013, and the number of publications increases every year.

Table 5 shows the most occurrent keyword for each cluster.

Results on entrepreneurial aspects

In addition to our bibliometric analysis on smart cities studies, we also investigate the entrepreneurial perspective in smart city studies in order to test our research questions and provide evidence.

As we reported in the previous bibliometric analysis, we look at the main findings associated with entreprenerial research in smart cities and published between 1997 and 2019. It's important to note that no contributions were published before 2008; for this reason we consider 2008–2019 as coverage period.

Table 5 Clusters composition

Cluster name	Authors' keywords and occurrences
AI and Big Data (two subclusters)	Data mining 34; social networks 18; data collection 12; clustering 11; smart parking 10; urban data 10
	Deep learning 11; smart homes 11
Smart city	Smart city 1688; internet of thing 561; big data 175; cloud computing 120; sustainability 86; wireless sensor networks 79; smart grid 74; security 62; sensors 54; energy efficiency 49
Technology and sustainability	ICT 38; sustainable development 34; sustainable city 23; blockchain 17; big data analytics 16; sustainable urban development 16; urban sustainability 15; sustainable cities 13; intelligent city 10; smart community 10
Social innovation and resilience	Resilience 12; social innovation 11
e-participation	Crowdsourcing 39; e-government 21; open innovation 19; smart governance 17; digital city 12; social media 12; ontology 12; visualization 12; smart government 11; user experience 10; human mobility 10; e-governance 10
Technology and privacy	Privacy 47; ubiquitous computing 15; urban computing 14; artificial intelligence 13; smartphone 12; participatory sensing 11
Process and data governance	Governance 36; open data 30; planning 24; technology 22; urban governance 17; urban 12; participation 12; intelligent cities 10
Smart mobility	Vanet 23; mobility 17; transportation 14; smart grids 12; performance evaluation 12; electric vehicles 12; its 12; quality of service 11; energy consumption 11; internet of vehicles 11
Pervasive computing	Pervasive computing 22; smart mobility 16; mobile 14; distributed systems 12; data analysis 10; augmented reality 10
Smart transportation infrastructure	Intelligent transportation systems 41; vehicular networks 15; crowdsensing 15; citizen participation 13; monitoring 12

This second-analysis was also conducted in January 2019 and achieved 53 publications[3] derived from 41 different sources (Journals, Books, etc.) with an average citation for each publication of 21.75.

According to the Fig. 8 below, smart cities research has witnessed a scarse productivity over the past years; the only 1 year that can be considered "productive" has been the 2018 with 26 publications indicating almost half than the total publications. We assume that during the 2019 the numbers will significantly increase and should overcome the 26 papers of the year before.

The figure shows that entrepreneurial-related issues in smart city research may represent an increasingly fastgrowing subdiscipline—especially in the past couple of years the number of publications in this area has increased dramatically.

We should expect that this growth will continue increasing over time in the future together with the number of authors and journals involved in this discipline.

The scientific community working in this sub-field of smart cities between 2008 and 2019 is made up of a few number of researchers. In order to assess their productivity and influence, a calculation was made to the quantity of source documents produced by each author: the most productive authors were Hollands RG, Kraus S, Kummitha RKR, Lee CS, Peris-Ortiz M, Richter C and Wiig A, with 2 publications each. Table 6 shows the most productive journals/proceeding series where ACM internationa conference proceeding series reports the higher number of papers published (4), followed by the journals "City" and "Technolgical Forecasting and Social Change" with 3 papers.

As done before, we perform the analysis on the keywords used by the authors in their contribution. Also in this case we refined the set of keywords, homogenising the terms used by the authors. (e.g. we found both terms "smart cities" and "smart city" among the keywords, then we edit the dataset in order to have just "smart city" in both cases). Figure 9 depicts the keywords co-occurrence graphs, considering keywords used at least in two papers of the dataset. It is possible to recognize three main clusters: one related to entrepreneurship and sustainability issues, a second one concerning policy integration, and another one concerning the entrepreneurial ecosystem.

In order to identify in a more appropriated way the cluster of topics debated in the dataset and their influence in the community (represented by the authors of the contributions belonging to the current dataset) we performed and in-depth analysis, reviewing the 53 papers, looking for a set of possible clusters. The review of the papers was done separately by two of the authors of the present contribution. After a first review, the two authors reached an agreement on both the number of clusters and their self-explicative names. Then, a second separated review round was carried out by the same authors, for assigning each paper to a specific cluster. Finally, comparing the review results, the authors discussed the divergent assignments in order to converge towards the same composition of each cluster. Table 1A in Appendix A shows the list of the 53 papers and the cluster to which belong.

On the basis of this analysis, we describe below the four resulting clusters.

- *Entrepreneurial capabilities* (7 papers): contribution discussing the need of entrepreneurial skills or competences in order to properly exploit the smart city

[3] The 53 publications are related to 28 articles, 5 articles in-press, 2 books, 4 book chapters, 13 conference papers and 1 short survey.

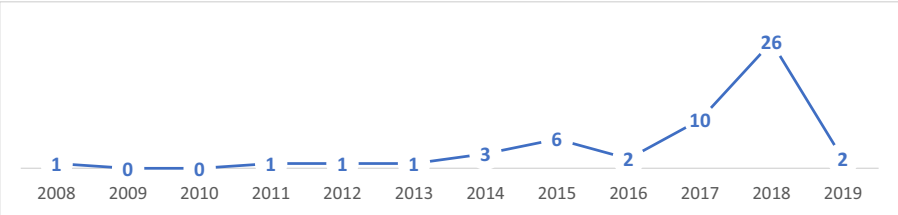

Fig. 8 Number of publications per year research since 2008

potentialities and to foster the transformation of ideas into products (Mamilla et al. 2018). In this cluster, some authors discuss how entrepreneurship should be included in the list of other competences, needed for acting in a smart city contenxt (Tryfonas and Crick 2018). Others suggest the use of living lab in order to foster entrepreneurial competence acquisition involving in some cases group of entrepreneurs (Sauer 2012).

- *Entrepreneurial practices* (18 papers): papers mainly based on case study. Some of them discuss aspects about the entrepreneurial attitude in pushing for technology adoption in order to reach the desired aim of city-level efficiency (Kummitha 2018). Others describe the adoption of some practices and mecchanism in the contenxt under investigation, such as hackatons, for fostering innovation, entrepreneurship and the start-up economy in smart cities (Perng et al. 2018), civic crowdfunding for the engagement, empowerment, and participation of citizens in entrepreneurial activities in smart cities context (Carè et al. 2018), as well as the use of open data in developping urban entrepreneurialism opportunities in smart city project (Barns 2016).
- *Entrepreneurship as perspective* (19 papers), papers mainly based on conceptual framework, in which the entrepreneurial perspective is taken into consideration. The most cited paper in the cluster discusses, criticizes and explores the concept of smart city, as a high-tech variation of the 'entrepreneurial city' (Hollands 2008). There are contributions investigating issues concerning specific geographic areas (Du Plessis and Marnewick 2017). Other papers consider several entrepreneurial aspects in investigating specific smart city phenomena, such as those characterizing smart city concept (Allwinkle and Cruickshank 2011) or the entrepreneurial ecosystems (Roth et al. 2013) among others.
- *Smart city governance* (9 papers), paper exploring how entrepreneurial aspects are crucial for smart city governance. Some authors debate about how competitive form of 'urban entrepreneurialism' limit ordinary people to participate in the smart city projects (Hollands 2015). Others investigate focus on policy mobility of the smart city as a mask for entrepreneurial governance (Wiig 2015). Some others explore the entrepreneurs' beliefs concerning smart city initiatives, suggesting that there is the need of a clear vision to drive smart city development and growth, considering the key role played by government in bringing the needed resources and stakeholders together (Kraus et al. 2015). Also among the contributions of this cluster there are authors moving some critiques, such as those criticizing the smart city concept often considered as a hegemonic notion of urban governance, transforming and supplanting planning (Krivý 2018).

Table 6 The most productive journals/proceeding series

Journals	N° of papers
1 ACM International Conference Proceeding Series	4
2 City	3
3 Technological Forecasting and Social Change	3
4 Business Horizons	2
5 City Culture and Society	2
6 Journal of Science and Technology Policy Management	2
7 Strategies and Best Practices in Social Innovation: An Institutional Perspective	2
8 Urban Geography	2
9 2014 International Conference on Web and Open Access to Learning ICWOAL 2014	1
10 2018 Global Internet of Things Summit GIoTS 2018	1
11 21st World Congress on ITSWC 2014	1
12 ASEE Annual Conference and Exposition Conference Proceedings	1
13 Cambridge Journal of Regions Economy and Society	1
14 Communicating the City: Meanings Practices Interactions	1
15 Creating Smart Cities	1
16 Creativity and Innovation Management	1
17 Entrepreneurship Innovation and Smart Cities	1
18 Environment and Planning A	1
19 Field Actions Science Report	1
20 Geoforum	1
21 IEEE Global Engineering Education Conference EDUCON	1
22 International Journal of Entrepreneurial Venturing	1
23 International Journal of Entrepreneurship and Small Business	1
24 International Journal of Knowledge and Systems Science	1
25 International Journal of Mechanical Engineering and Technology	1
26 Journal of Business Research	1
27 Journal of Environmental Policy and Planning	1
28 Journal of Rural Studies	1
29 Journal of Theoretical and Applied Electronic Commerce Research	1
30 Journal of Urban Technology	1

Discussion and conclusion

Most entrepreneurship research focuses on entrepreneurial activities in large urban areas (Roundy 2019). In addition, smart city contexts should consider entrepreneurial activity including risk-taking, innovation, opportunity identification, and value creation. One important challenge surrounding entrepreneurship in the smart city context is based on the concept of commitment of individual or groups to a new venture creation. Entrepreneurship in smart cities is obviously risky because of market pressures and it will be important to identify

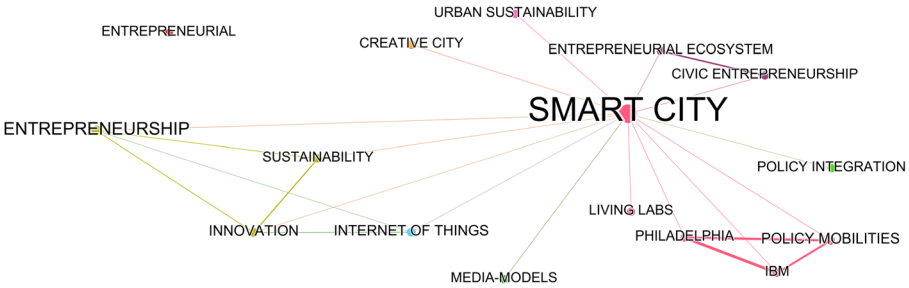

Fig. 9 Keywords co-occurrence graph

several specific strategies that smart cities can use to support entrepreneurial activity. Those strategies that can encourage entrepreneurship and it is necessary to identify the specific mechanisms driving these effects.

The growing academic interest during the past three decades in the field of smart cities (Appio et al. 2019; Mora et al. 2017; Neirotti et al. 2014; Schiavone et al. 2019) is evident through the remarkable growth the number of published papers, books, chapters and conference proceedings. Although this field is growing, there is still a need to study what are the entrepreneurial conditions enabling the development of smart cities (Leydesdorff and Deakin 2011; Kraus et al. 2015; Mora et al. 2017; Komninos and Mora 2018). In light of prior studies that highlight the need of classifying the research area based on the main trends (Adriaanse and Rensleigh 2013; Bjork et al. 2014), we perform two bibliometric analyses: the first showing the evolutionary trends of research in the field of Smart Cities, in general, and the second taking into consideration the entrepreneurial perspective. Our analyses help to identify not only the main themes in the literature, but also the existing gaps and new relevant lines of research.

By identifying several clusters of debated topics, we aim at enhancing the discussion of the entrepreneurial aspects in smart cities context. According to the cluster analysis, we should focus on what are the entrepreneurial skills needed for improving the smart city context, what can be entrepreneurial practices and mechanisms to achieve the expected level of smart-city efficiency. Some authors discussed the civic crowdfunding in entrepreneurial activities together with the massive usage of open data in reaching urban opportunities in smart city context. Furthermore, discussion is active in designing the proper conceptual framework of entrepreneurial perspective and also in exploring how entrepreneurial aspects are critical for the governance of smart cities. Discussion has been also made on the need of a clear vision to drive smart city development and growth, taking into account the important role played by government in bringing the needed resources and stakeholders together (Kraus et al. 2015).

The main contribution of this paper lies in the categorization or classification of the vast amount of publications focused on smart cities, in general, and on entrepreneurship on smart cities over the period 1997–2019 and the identification of some relevant gaps within each of these classifications. The situation

showed in the second bibliometric analysis implies that further research is necessary for the advancement of understanding in this area. We contribute to the literature on entrepreneurship in the three following ways: offering a bibliometric analysis on the past scientific contributions debating smart cities, by integrating other bibliometric works such as Mora et al. (2017), covering also the period after 2012; investigating the collaboration among the authors, the relation between the knowledge creation process of the specific research community and the impact of its research results; using the same approach to investigate the entrepreneurial perspective in smart city studies. Above all, we have identified and critically discussed the scientific production of smart cities literature and the related entrepreneurial aspects, underlining the main foundations of the dissertation. Entrepreneurship in smart cities represents a research field that is moving toward maturity while accumulating an understanding of the role of the entrepreneur in society.

Implications, limitations and future directions

An increasing number of studies underline that entrepreneurship discipline should pay more attention to the contexts in which entrepreneurial activities take place, thus, to the context of smart cities. Specifically, following previous works (Fitz-Koch et al. 2018; Baier-Fuentes et al. 2018), we identify not only the main themes in the literature, but also the existing gaps, new relevant lines of research as well as outline suggestions for how entrepreneurship scholars can approach in future research and thereby deepen our understanding of how entrepreneurship happens in the context of smart cities.

Our study has several implications for various users. Entrepreneurs may find inspiration and ideas and turn them into successful behaviors (Liñán and Fayolle 2015). Policy makers will find relevant material to rethink and improve their public policies aimed at increasing the level of entrepreneurial process among people and citizens in smart cities context.

This work also presents also several limitations, mainly associated with our methodology used and data collection. Despite we have covered a consistent time-period in our analysis, the application of bibliometric approach induces constraints. Since publications need time to show a significant impact, we can only report and make comments on past trends without predicting which contributions will be the most influential in future studies. We will appreciate insights and novel ideas, which provide a better understanding of smart cities and we also hope that our study will result in a greater integration of entrepreneurship and international business research activity. Future studies will identify several specific strategies that smart cities can use to support entrepreneurial activity; they will also determine what strategies are the most influential for encouraging entrepreneurial growth (Roundy 2018). Those strategies will allow a greater understanding of the process of smartization (Schiavone et al. 2019) that may help cities to "*maintain the essence of their community identities, traditions, and cultures while engaging in the transformations necessary to secure a place in the modern economy*" (Roundy, 2018, p.23).

Appendix A

Table 1A Clusters composition for "entrepreneurship in smart city" dataset

Authors	Title	Source title	Year	Doc. type	Cluster
Kummitha R.K.R., Crutzen N.	Smart cities and the citizen-driven internet of things: A qualitative inquiry into an emerging smart city	Technological Forecasting and Social Change	2019	Article	Smart city governance
Martin C., Evans J., Karvonen A., Paskaleva K., Yang D., Linjordet T.	Smart-sustainability: A new urban fix?	Sustainable Cities and Society	2019	Article	Smart city governance
Krivý M.	Towards a critique of cybernetic urbanism: The smart city and the society of control	Planning Theory	2018	Article	Smart city governance
DeWit A.	Japanese Smart Communities as Industrial Policy	Sustainable Cities and Communities Design Handbook: Green Engineering, Architecture, and Technology	2017	Book Chapter	Smart city governance
Santos D.	Mind the gap: Smart cities and entrepreneurship policies	ACM International Conference Proceeding Series	2017	Conference Paper	Smart city governance
Pierce P., Ricciardi F., Zardini A.	Smart cities as organizational fields: A framework for mapping sustainability-enabling configurations	Sustainability (Switzerland)	2017	Article	Smart city governance
Kraus S., Richter C., Papagiannidis S., Durst S.	Innovating and Exploiting Entrepreneurial Opportunities in Smart Cities: Evidence from Germany	Creativity and Innovation Management	2015	Article	Smart city governance
Wiig A.	IBM's smart city as techno-utopian policy mobility	City	2015	Article	Smart city governance
Hollands R.G.	Critical interventions into the corporate smart city	Cambridge Journal of Regions, Economy and Society	2015	Article	Smart city governance
Peters D.J., Hamideh S., Zarecor K.E., Ghandour M.	Using entrepreneurial social infrastructure to understand smart shrinkage in small towns	Journal of Rural Studies	2018	Article	Entrepreneurship as perspective
Andersson I., James L.		Urban Studies	2018	Article	

Table 1A (continued)

Authors	Title	Source title	Year	Doc. type	Cluster
	Altruism or entrepreneurialism? The co-evolution of green place branding and policy tourism in Växjö, Sweden				Entrepreneurship as perspective
Alonso-Gonzalez A., Chacon L.A.P., Peris-Ortiz M.	Sustainable social innovations in smart cities: Exploratory analysis of the current global situation applicable to Colombia	Strategies and Best Practices in Social Innovation: An Institutional Perspective	2018	Book Chapter	Entrepreneurship as perspective
Peris-Ortiz M., Gomez J.A., Marquez P.	Strategies and Best Practices in Social Innovation: An Institutional Perspective	Strategies and Best Practices in Social Innovation: An Institutional Perspective	2018	Book	Entrepreneurship as perspective
Wyly E., Daniels J., Dhanani T., Yeung C.	Hayek in the cloud*: Conservative cognition and the evolution of the smart city	City	2018	Article	Entrepreneurship as perspective
Datta A.	'Cityzens become netizens': Hashtag citizenships in the making of India's 100 smart cities	Creating Smart Cities	2018	Book Chapter	Entrepreneurship as perspective
Visser R.	Posthuman policies for creative, smart, eco-cities? Case studies from China	Environment and Planning A	2018	Article	Entrepreneurship as perspective
Bittencourt B.A., Zen A.C., Schmidt V., Wegner D.	The orchestration process for emergence of clusters of innovation	Journal of Science and Technology Policy Management	2018	Article	Entrepreneurship as perspective
Sarma S., Sunny S.A.	Civic entrepreneurial ecosystems: Smart city emergence in Kansas City	Business Horizons	2017	Article	Entrepreneurship as perspective
Du Plessis H., Marnewick A.L.	A roadmap for smart city services to address challenges faced by small businesses in South Africa	South African Journal of Economic and Management Sciences	2017	Article	Entrepreneurship as perspective
Gaeiras B.	Fablab Lisboa: When a municipality fosters grassroots, technological and collaborative innovation	Field Actions Science Report	2017	Article	Entrepreneurship as perspective
Ratten V.	Entrepreneurship, innovation and smart cities	Entrepreneurship, Innovation and Smart Cities	2017	Book	Entrepreneurship as perspective
Lampugnani D.	Questioning the smart city: From techno-entrepreneurial to intelligence-enabling	Communicating the City: Meanings, Practices, Interactions	2017	Book Chapter	Entrepreneurship as perspective
			2015		

Table 1A (continued)

Authors	Title	Source title	Year	Doc. type	Cluster
De Falco S., Polese F., Angrisani M.	Innovation and entrepreneurship in smart cities: The role of research centres in marginal urban areas	Proceedings of the European Conference on Innovation and Entrepreneurship, ECIE		Conference Paper	Entrepreneurship as perspective
Edelstein R.	Smarter transportation management through its	21st World Congress on Intelligent Transport Systems, ITSWC 2014: Reinventing Transportation in Our Connected World	2014	Conference Paper	Entrepreneurship as perspective
Di Staso U., Magliocchetti D., De Amicis R.	Smart-Islands: Enhancing user experience for mediterranean Islands for tourism support	Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)	2014	Conference Paper	Entrepreneurship as perspective
Roth S., Kaivo-Oja J., Hirschmann T.	Smart regions: Two cases of crowdsourcing for regional development	International Journal of Entrepreneurship and Small Business	2013	Article	Entrepreneurship as perspective
Allwinkle S., Cruickshank P.	Creating smart-er cities: An overview	Journal of Urban Technology	2011	Article	Entrepreneurship as perspective
Hollands R.G.	Will the real smart city please stand up? Intelligent, progressive or entrepreneurial?	City	2008	Article	Entrepreneurship as perspective
Kummitha R.K.R.	Entrepreneurial urbanism and technological panacea: Why Smart City planning needs to go beyond corporate visioning?	Technological Forecasting and Social Change	2018	Short Survey	Entrepreneurial practice
Leorke D., Wyatt D., McQuire S.	"More than just a library": Public libraries in the 'smart city'	City, Culture and Society	2018	Article	Entrepreneurial practice
Perng S.-Y., Kitchin R., Mac Donncha D.	Hackathons, entrepreneurial life and the making of smart cities	Geoforum	2018	Article	Entrepreneurial practice
Beliatis M.J., Mansour H., Nagy S., Aagaard A., Presser M.	Digital waste management using LoRa network a business case from lab to fab	2018 Global Internet of Things Summit, GIoTS 2018	2018	Conference Paper	Entrepreneurial practice
Indrawati, Azkalhaq N., Amani H.	Indicators to measure smart economy: An Indonesian perspective	ACM International Conference Proceeding Series	2018	Conference Paper	Entrepreneurial practice
			2018	Article	

Table 1A (continued)

Authors	Title	Source title	Year	Doc. type	Cluster
Angelidou M., Psaltoglou A., Komninos N., Kakderi C., Tsarchopoulos P., Panori A.	Enhancing sustainable urban development through smart city applications	Journal of Science and Technology Policy Management			Entrepreneurial practice
Carè S., Trotta A., Carè R., Rizzello A.	Crowdfunding for the development of smart cities	Business Horizons	2018	Article	Entrepreneurial practice
Tokunaga S., Martinez M., Crusat X.	Engaging on entrepreneurship: The effectual logic behind the entrepreneurship journey	IEEE Global Engineering Education Conference, EDUCON	2018	Conference Paper	Entrepreneurial practice
Praharaj S., Han J.H., Hawken S.	Urban innovation through policy integration: Critical perspectives from 100 smart cities mission in India	City, Culture and Society	2018	Article	Entrepreneurial practice
Cowley R., Joss S., Dayot Y.	The smart city and its publics: insights from across six UK cities	Urban Research and Practice	2018	Article	Entrepreneurial practice
Ferraris A., Belyaeva Z., Bresciani S.	The role of universities in the Smart City innovation: Multistakeholder integration and engagement perspectives	Journal of Business Research	2018	Article	Entrepreneurial practice
Lee C.-S., Kuok-Shoong D.W.	Deriving a gamified learning-design framework towards sustainable community engagement and mashable innovations in smart cities: Preliminary findings	International Journal of Knowledge and Systems Science	2018	Article	Entrepreneurial practice
Grimaldi D., Fernandez V., Carrasco C.	Heuristic for the localization of new shops based on business and social criteria	Technological Forecasting and Social Change	2018	Article	Entrepreneurial practice
Haarstad H.	Constructing the sustainable city: examining the role of sustainability in the 'smart city' discourse	Journal of Environmental Policy and Planning	2017	Article	Entrepreneurial practice
Wiig A.	The empty rhetoric of the smart city: from digital inclusion to economic promotion in Philadelphia	Urban Geography	2016	Article	Entrepreneurial practice
Barns S.	Mine your data: open data, digital strategies and entrepreneurial governance by code	Urban Geography	2016	Article	Entrepreneurial practice
Richter C., Kraus S., Syrjä P.	The Smart City as an opportunity for entrepreneurship	International Journal of Entrepreneurial Venturing	2015	Article	Entrepreneurial practice
Lea R., Blackstock M.	Smart cities: An IoT-centric approach		2014		

Table 1A (continued)

Authors	Title	Source title	Year	Doc. type	Cluster
		ACM International Conference Proceeding Series		Conference Paper	Entrepreneurial practice
Mamilla R., Swamy T.N.V.R., Chirayath S.	Effect and influence of HR and financial services in the expansion of manufacturing sector in India	International Journal of Mechanical Engineering and Technology	2018	Article	Entrepreneurial capabilities
Tryfonas T., Crick T.	Public policy and skills for smart cities: The UK outlook	ACM International Conference Proceeding Series	2018	Conference Paper	Entrepreneurial capabilities
Santiago J.M., Jr., Guo J.	Developing an entrepreneurial mindset using the KEEN framework for a digital communication system course	ASEE Annual Conference and Exposition, Conference Proceedings	2018	Conference Paper	Entrepreneurial capabilities
Lee C.-S., Wong K.D.	An entrepreneurial narrative media-model framework to knowledge building and open co-design for smart cities	Proceedings of Computing Conference 2017	2018	Conference Paper	Entrepreneurial capabilities
Tanda A., De Marco A., Rosso M.	Evaluating the impact of smart city initiatives the Torino living lab experience	SMARTGREENS 2017 - Proceedings of the 6th International Conference on Smart Cities and Green ICT Systems	2017	Conference Paper	Entrepreneurial capabilities
Andone D., Holotescu C., Grosseck G.	Learning communities in smart cities. Case studies	2014 International Conference on Web and Open Access to Learning, ICWOAL 2014	2015	Conference Paper	Entrepreneurial capabilities
Sauer S.	Do smart cities produce smart entrepreneurs?	Journal of Theoretical and Applied Electronic Commerce Research	2012	Article	Entrepreneurial capabilities

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