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Review

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The Roadmap to Smart Cities: A Bibliometric Literature Review on Smart Cities' Trends before and after the COVID-19 Pandemic

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Abstract: The smart city has been a growing utopia, a brilliant image of a city of the future, in the past twenty years. Since its birth, at the end of the previous century, several changes have been seen in urban areas, both aligned and detached from this concept. On the one side, digital implementation seems to be growing in all the major cities, especially in the service sector, which are experiencing a proliferation of new solutions, tools and modalities of interactions. On the other side, new concepts are rising such as the "digital twin", the "15-minute city", and the "metaverse city", evidencing both the necessity to continuously innovate and reach higher levels of digitalization but also the need to focus on people's life. This paper aims to provide a contribution to the understanding of the concept's evolution at the forefront of climate change with the aim to detect the elements of innovation, focusing on implementation roadmaps and trends but also searching for evolutions in research due to the COVID-19 pandemic. The hypothesis is that some changes of direction could have been triggered by the pandemic due to the urgency of finding concrete solutions. The conclusions will show that it is possible to detect some of them, especially in the technological domain.

Keywords: smart city; COVID-19; climate change; transition roadmap; pandemic; bibliometric; drivers; trends

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1. Introduction

The smart city has been a growing utopia, a brilliant image of a city of the future, for the past twenty years [1–3]. Since its birth, at the end of the previous century, several changes have been seen in urban areas, both aligned and detached from this concept. Many cities have started the application of this concept in their proper contexts, usually starting from the implementation of innovative services, i.e., in mobility, governance, healthcare, education and others. As stated in many contributions [4–11], the smart city concept arose at the end of the previous century when the first attempts to connect digital and physical environments were made by some cities (e.g., Amsterdam and Barcelona) and big companies, such as IBM and Cisco [12]. However, several researchers have noted [12] that it was around 2015 that the topic started to be in the spotlight. Since 2015, it is possible to see a high increase in research contributions published on the smart city topic, a trend that is growing still today. This is also why there is a necessity to perform recurrent and updated literature reviews on the topic, in order to understand its evolutions and, even more, its trends and potential future developments [12].

On the one side, digital implementation seems to be growing in all the major cities, especially in the service sector, which is experiencing a proliferation of new solutions, tools and modalities of interactions. On the other side, new concepts are rising such as the "digital twin" [13], the "15-minute city" [14–16], and the "metaverse city" [17], evidencing both the necessity to continuously innovate and reach higher levels of digitalization but also the need to focus on people's life. The new challenges such as the COVID-19 pandemic, the energy crisis, growingly unstable political environments, climate change and the need to support the climate transition [18–20] are putting at the forefront the urgency of finding

real pathways and new sets of solutions able to produce systematic changes, more than single innovations. It is commonly accepted that smart cities can be a way to address all these issues, as technologies can support policies and urban management in multiple domains, including climate change mitigation and adaptation. However, a precise pathway or a "best strategy" to transform a city into a smart one does not seem exist, yet. On the one hand, each city has its own necessities and peculiarities, but on the other hand, it is also true that cities have common barriers and challenges. The search for a common pathway of transition is justified by these common aspects: all cities aim to become more efficient, better able to solve people's problems, and to become more climate neutral, more resilient, and so on.

This paper aims to provide a contribution to the understanding of the smart city concept at the forefront of climate change and current challenges, with the aim to detect recurring elements of innovation, trends, and the rising of specific transition pathways, by querying the existing scientific production. One hypothesis behind the contribution is that some of the last events, and in particular COVID-19, could have produced changes in how the smart city is perceived and implemented, due to the urgency of finding concrete and precise solutions. In the next sections, I will explore this hypothesis by performing a bibliometric analysis on the Web of Science database of published works. In particular, Section 2 deepens a qualitative literature review focusing on some of the most interesting contributions on the themes of current and future trends, with the objective to provide insights on what has already been covered recently. The same section will also identify the research questions behind this contribution. Then, Section 3 will highlight the methodology and the tools used for the bibliometric analysis. Section 4 will show the results, Section 5 will provide the discussion and, finally, Section 6 some conclusions and future potential paths of research.

2. Qualitative Literature Review and Research Questions

The smart city has been a growingly popular topic in political and research agendas in the last decades. As pointed out by Sharifi et al. [12], interest in the concept has risen sharply since 2010, probably after the consistent campaign promoted by IBM at the end of the 2000s. However, the real starting point in the fast growth of the concept seems to be 2015. This is evident while performing a simple query on Scopus or Web of Science. Around those years, multiple contributions were influenced by the publication of the 2030 agenda, the New Urban Agenda, the Paris Climate Agreements [12] but also by one of the first official reports on smart cities by the European Commission [21]. Since then, the concept of the smart city took many different specifications and directions. As I mentioned in a previous publication [2], it almost seems that all the sectors having some relations with cities started to see their potential contribution in the field and, consequently, started to propose new solutions, technologies, tools, and actions based on the specificities of their work. In the years, contributions were produced from many domains and fields from electrical engineering to sociology, from information technologies to the economy. This is due to the complexity that the topic entails: a smart city deals with cities, which are very complex systems made of multiple layers and nodes, and where multiple elements interact and produce effects on the others [10,22,23]. According to Camero and Alba [24] and as reported also by [12] and many others [4,5,8,10,25–27], the absence of a shared definition of the concept is causing a proliferation of different points of view that are mainly conducted in non-permeable silos and that usually refer to a specific scientific domain. There is a lack of deep understanding of the concept in its multiple facets and its complexity. Cities are permeable entities created and inhabited by humans, who are unpredictable. It is quite difficult to capture the entire complexity of cities and their evolution, and this is also applicable to the smart city concept. Often smart cities are divided into sectors of application [28], and this subdivision is, on the one hand, useful to better identify specific measures to implement, but on the other hand, contributed to a sectionalization of the concept's understanding. These sectors are smart economy [29], smart people [6,30,31], smart governance [32–34], smart mobility [35–37],

smart environment [38–41] and smart living [42–44]. Over the years, these sectors have framed the scientific publications on the smart city, with authors mainly aligning, albeit with this structure, eventually with some additions and modifications. As an example, a growing attention in the last years has been placed on security issues [45,46], education [47], health [48,49], energy [50–52] and performance [53–55]. The body of literature around the smart city is mainly focused on proposing, analyzing and reporting innovations mainly in terms of new technologies, tools, and strategies to be applied in the sector. In parallel, there is a growing theoretical body of literature targeting the identification of trends and future development of the concept implementation. This is a growing sector of research, especially in the last years [8,10,12,50,56–68], where several bibliometric and systematic literature reviews have been developed.

According to Yigitcanlar et al. [68], it is possible to identify three types of drivers within which the smart city seems to align—community, technology and policy—and five frequent outcomes—productivity, sustainability, accessibility, wellbeing, livability and governance. Sharifi et al. [12] refer to domination of the two core aspects of conceptual issues and technical aspects as the main two groups into which research is currently divided. They divided their analysis focusing on two periods: 1991–2015 and 2016–2022. In the first period, they registered a predominance of conceptual contributions and technical aspects, while in the second period, they pointed out an increased link between the term "smart city" and "climate change" or "sustainability", constituting a growing attention to the linkages between the two. Janik et al. [67] refer to a connection between smart and sustainable cities, defining the term smart sustainable City (SSC). In their paper, they put in evidence a threefold nature of the concept: (1) it is linked with information and communication technologies, (2) it should be sustainable in the sense of not compromising the ability of future people to meet their needs, (3) it should not exceed environmental limitations. Fosso Wamba and Maciel [66] proposed a review mainly focused on the authors that are working on the topic. Zhao et al. [65] also proposed a general overview of the topic, identifying four key directions (research objectives and development-strategy research, technical-support research, data processing and applied research, and management and applied research) and some research frontiers (urban development, sustainable cities, cloud computing, artificial intelligence, integration).

COVID-19 hit the world at the end of 2019, with its major intensity in 2020, when countries worldwide had to face lockdowns and had to implement new ways of reconsidering and replanning the urban space. Digital applications and services saw a boost within this period [69]. As highlighted by Sharifi et al. [69], smart city applications have shown their capacity to support cities within this specific crisis. The authors conclude by referring to the potentialities that smart city applications can have to increase cities' resilience. However, it is interesting to verify whether there has been a change of interest in publications on smart cities and an increase in practical aspects such as roadmaps and pathways.

As evidenced by the synthetic qualitative literature review proposed here, the general smart city concept is quite well covered by recent bibliometric research, especially in its more general and theoretical aspects. Many papers identify the most recurrent terms and connections, trying to identify future trends. However, more specific and in-depth research seems to be absent up to now. As a consequence, this paper aims to cover part of the actual existing gaps, by proposing a bibliometric review of the smart city topic in connection with two elements:

- the presence of pathways and/or roadmaps of implementation inside the scientific literature;
- the potential evolution of the smart city trends before and after the COVID-19 pandemic.

The objective of the paper is to review the most recent literature and provide reflections for the prosecution of the research on the smart city.

Thus, the research questions (RQ) underlying this review paper are the following:

- RQ1: Is it possible to see some evolutions or changes in smart city trends before and after the COVID-19 pandemic?

- RQ2: Are roadmaps and pathways linked with smart-city-related scientific production? Is there an increase in attention to these types of publications after the COVID-19 pandemic?

3. Materials and Methods

This review paper uses the methodology of bibliometric research with the aim of identifying patterns and trends through bibliometric analysis. To perform this analysis, a systematic literature review was performed in the Web of Science Core Collection database. Data were analyzed through the VOSviewer tool.

The Web of Science (WoS) database was chosen for its reputation in indexing high-standard and peer-reviewed papers and for the substantial presence of the smart city topic in the collections. Additionally, WoS allows for downloading formats that are compatible with VOSviewer, and it provides some analysis of citations and results that are useful to direct the search and immediately have insights on emerging aspects. As referred to in the Conclusions section, the inclusion of other databases, such as Scopus, will be considered in further publications. In order to include all the relevant contributions and to answer the research questions, several entries were considered in WoS, as detailed in Table 1. The literature search was conducted between August and November 2022, with two final checks for new papers on the 4th and 26th of November 2022.

Table 1. Detail of the literature search on Web of Science.

Query Wording	Details	N° of Appearances
"Smart city" OR "Smart cities" AND "city"	"Smart city" in title "City" in topic	4366
"Smart city" OR "Smart cities" AND "city" AND "trend"	"Smart city", "city" in topic "Trend" in title	86
"Smart city" OR "Smart cities" AND "city" AND "trend" AND "2017–2019"	"Smart city", "city" in topic "Trend" in title "2017–2019" in timeframe	37
"Smart city" OR "Smart cities" AND "city" AND "trend" AND "2020–2022"	"Smart city", "city" in topic "Trend" in title "2020–2022" in timeframe	38
"Smart city" OR "Smart cities" AND "roadmap"	"Smart city" in topic "Roadmap" in title	18
"Smart city" OR "Smart cities" AND "roadmap" AND "2017–2019"	"Smart city" in topic "Roadmap" in title "2017–2019" in timeframe	8
"Smart city" OR "Smart cities" AND "roadmap" AND "2020–2022"	"Smart city" in topic "Roadmap" in title "2020–2022" in timeframe	5

The literature search saw different tentatives and phases. The first one was a general search including "smart city" and "city" in the topic. This was important to understand the general response of the database and to check the big picture of the topic. The word "city" was added in order to focus on the literature, more focusing specifically on city-related research and not on other specifications of the smart city (e.g., development of new software with no direct reference to cities). After this general search, which can perform both a qualitative literature analysis and produce the first bibliometric insights, more precise queries were performed including different types of wording.

In order to check the presence of changes during and after the COVID-19 pandemic, two timeframes were also identified as a further refinement of the search. The two timeframes selected were 2017–2019 for the first one and 2020–2022 for the second one. Both are of the same length (3 full years). To understand the role of pathways and roadmaps, specific keywords were added to the query. After some tentatives, the focus was eventually placed on the word "roadmap" instead of both "roadmap" and "pathway" because the results were more representative. "Pathway" seems to be very used in medical science (oncology and

other medical sectors), creating false results for the objectives of this study. Excluding specific fields (i.e., medical ones), the number of results were very high and not representative for the objectives of this paper. The combination of both words, even with successive refinements, produced a very high number of results (around 300 k) not in line with the research questions of this review paper. Table 1 details the entire process and results.

The totality of the literature entries was then screened to avoid duplications and to exclude papers off topic. In addition, only English-written contributions were selected, and no exclusions were made for document types. The final number of papers considered in total was 103 for the detailed analysis and 4289 for the general analysis. The 103 papers were then read in the title and abstract, and the 10 most cited per each query wording (for a total of 60 papers) were completely and carefully read in their full length. The in-depth readings were necessary and used to check if some key aspects of the topic were not emerging into the co-occurrence maps and to avoid missing some crucial aspects in the analyses. Additional contributions were selected following a qualitative approach while scanning the entire database and were used to perform the qualitative reviews.

To perform the bibliometric analysis, both the embedded tools of WoS and VOS viewer were used. VOSviewer [70] is an open-source software, freely available and downloadable for all operating systems (https://www.vosviewer.com/, accessed on 4 December 2022). Many papers were published recently with the use of VOSviewer in many fields of research [12,71–73].

The software allows for correlating terms referred to in the literature such as terms included in titles and abstracts but also authors and journals. The software can also perform a cleaning process by adding Thesaurus files. This file was created for each of the analyses performed and was added to the tool to avoid duplications, double counting, and to normalize abbreviations, etc. After having obtained the first results, clusterization parameters were changed in order to obtain a relevant number of clusters and, thus, a more relevant map. Details on this process are provided at the beginning of each subsection of Section 3. If not differently specified, all analyses performed with VOSviewer were created from text data to obtain maps showing the co-occurrence of terms in titles and abstracts. The input files were bibliographic database files downloaded from WoS. The selected counting was binary to avoid double counting on the same paper. The minimum number of occurrences in the entire database was put to 5, in order to exclude terms appearing in less than 5 documents.

However, as reminded in Zheng et al. [62] and recalling many authors [74,75], hybrid techniques were used to perform the analysis, mixing both qualitative and quantitative approaches. Additional papers were carefully read in total following a qualitative approach; then, the 10 most cited ones were used per analysis. The results of this qualitative reading are included in the literature review section.

The next section proposes the results of this study.

4. Results

In this section, a comprehensive, although synthetic, overview of the main results of the analysis is presented. This section is divided into sub-paragraphs, each of which report the results of a specific query.

4.1. Overall Analysis of the Smart City General Query

This analysis was performed to provide an updated understanding of the smart city topic, to support the qualitative literature review. The totality of papers was entered, in an appropriate format, into the VOSviewer software, selecting the analysis on words co-occurrence both in titles and abstracts. Binary counting was then selected, and five was the minimum number of term co-occurrence to be shown on the map. The normalization was performed with the association strength method. A cleaning phase was also performed, checking the totality of considered words and adding a thesaurus file, which forced the system to exclude terms that were not relevant to avoid duplications (i.e., singular and plural

words) and to avoid double-counting (i.e., with abbreviations), as explained in Section 2. Optimizations were also performed in the number of clusters to obtain the best possible number. Each cluster contained at least 140 words. The results are shown in Figure 1.

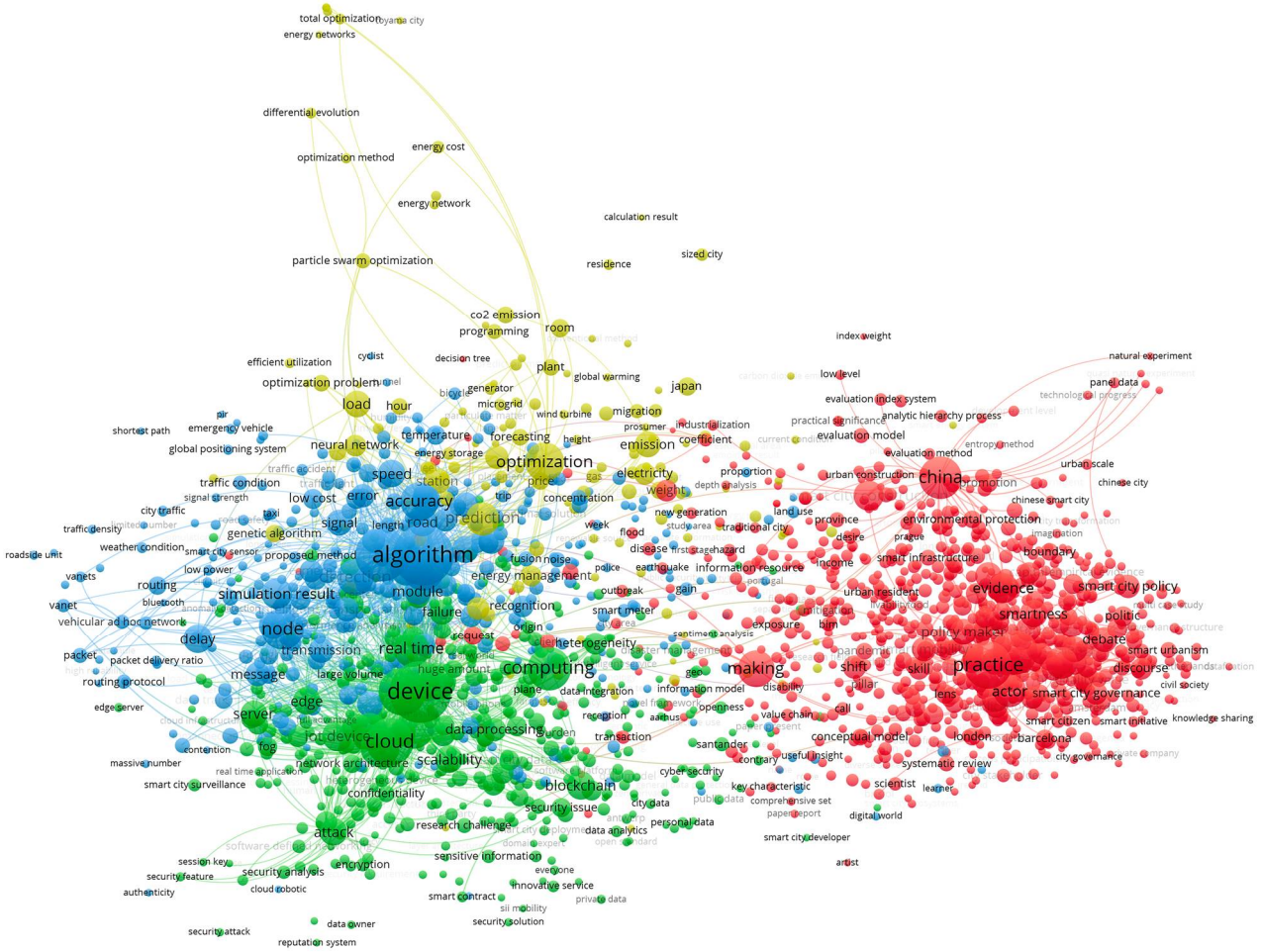

Figure 1. The output of the term co-occurrence analysis for the whole smart city topic, performed in VOSviewer. The figure shows the physical distances among terms present in titles and abstracts of the literature analyzed, providing clusters of networks of co-occurring terms.

The map is clustered into four thematic groups: red, blue, green and yellow. Even with this clusterization, it is evident how the topic has a multiplicity of keywords. Three of the categories are quite homogeneous: red, blue and green, while the yellow one seems more sparse and distant. VOSviewer co-occurrence analysis shows the distance between words, meaning that the physical distance between two words in the graph corresponds to a greater distance in the research topics.

The red cluster seems to be dominated by governance/political agendas/implementation-related words, including for example "smart city initiative" and other words such as "smart city policy", "actor", "urbanism", "smart economy", "economic growth", "smartness", and "debate". They mainly refer to the theoretical part of the concepts and their main characteristics. The word "pandemic" is also present, even if it seems not really linked with others.

The green cluster refers to the cloud and big-data-related words, including "blockchain", "cloud", "storage", "device", "scheme", "protocol", "IoT device", "edge computing", "scalability", and "smart meter". It is possible to refer to it as the big data analytic cluster. This cluster is smaller than the previous one with very precise and concentrated terms, typical of technical research fields.

The blue cluster, which is the third in terms of numerosity of words, contains topics related to the operational part of the Internet of Things, such as "algorithm", which is the

most important one, but also "accuracy", "neural network", "forecasting", "prediction model", "deep learning model, "prediction accuracy" and similar.

The fourth cluster is the yellow one. This is a less homogeneous cluster, having words linked to many of the others. It is related to the monitoring world, including terms such as "air pollution", "meters", "temperature", "air", "humidity", and "calibration". It is not surprising that these terms emerge, as the smart metering aspects of smart cities are quite present in the literature and constitute an important part of the topic. It is however surprising that in most of the previous bibliometric analyses, this cluster does seem not to appear as a stand-alone one. One reason can be the growing relevance that measurements are meeting in the last years or its inclusion in another one.

This general analysis is interesting because it seems that the smart city topic is actually divided into four core themes—theoretical aspects, Internet of Things processes, big data, and another one that is gaining attention and relevance, the monitoring and sensors one.

4.2. Analysis of Smart City Trends in General and in the Selected Timeframes

In this sub-section, a co-occurrence analysis was performed to verify the actual smart city trends as referred to in the scientific literature production. To do this, the WoS query included the word "trend" as a keyword present in the titles. The results of this search included many systematic and review papers analyzing current and potential future trends of the smart city topic.

To identify the latest reflections and to check if there was any change in these after the COVID-19 pandemic, three analyses were performed:

1. a general one, including the entire timeframe available in the WoS database;
2. a second one, limited to the 2017–2019 timeframe;
3. a third one, limited to the 2020–2022 timeframe.

The two timeframes displayed a smaller number of papers, thus requiring performing a qualitative analysis of the publication themselves. A specific cleaning process was also performed within this analysis, deleting, in particular, words related to review papers that would have falsified the analyses (i.e., contribution, year, trend, future trends, publication, research, work and similar). The clusters were also optimized by increasing the minimum number of words per cluster to 12, to avoid too small clusters and to have the optimal number of them.

Figures 2–4 show the VOSviewer results of co-occurrence words (titles and abstracts) in the complete amount of papers (Figure 2 the network, Figure 3 the density and Figure 4 the detail), while Figures 5 and 6 show the two specific timeframes before and after the COVID-19 pandemic.

The general analysis, both in the network and in the density visualization, shows an interesting variety of terms recurring in papers that aim to provide insight into smart city trends. Figures 2 and 3 show the presence of three clusters: green, blue and red.

The three clusters are quite balanced, but the bigger one is the red one. This cluster collects words about artificial intelligence, big data and data, with some linked sectors such as energy and transportation. The use of the word "transportation", instead of "mobility" in this cluster is interesting, as it is linked with data and real data. Energy is an increasing trend in data measurements and sensors. An additional interesting element is constituted by the "blockchain" term, which is present in the blue cluster. If we isolate it (as showed in Figure 4), it is interesting to see its connections.

This visualization is obtained by clicking the word inside the software. It is relevant, as it can check specific connections of a specific term. In this case, it is evident how the term constitutes an interesting development trend and how it is linked with many others. It is not only strictly linked with the data cluster, but also with both the IoT cluster and the concept one, being linked with words such as "population", "mobility", "citizen", "process", and "urban area". This is also confirmed by different authors such as in [76–79].

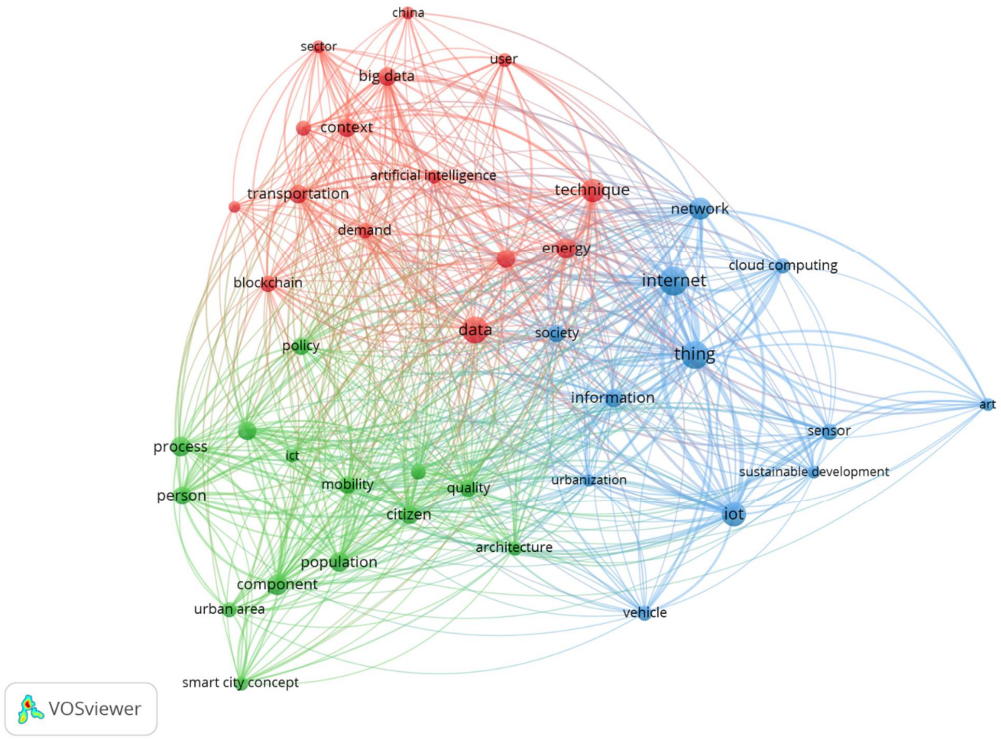

Figure 2. The output of the term co-occurrence analysis for the whole smart city + trend topic, performed in VOSviewer. Network visualization. The figure shows the physical distances among terms present in titles and abstracts of the literature analyzed, providing clusters of networks of co-occurring terms.

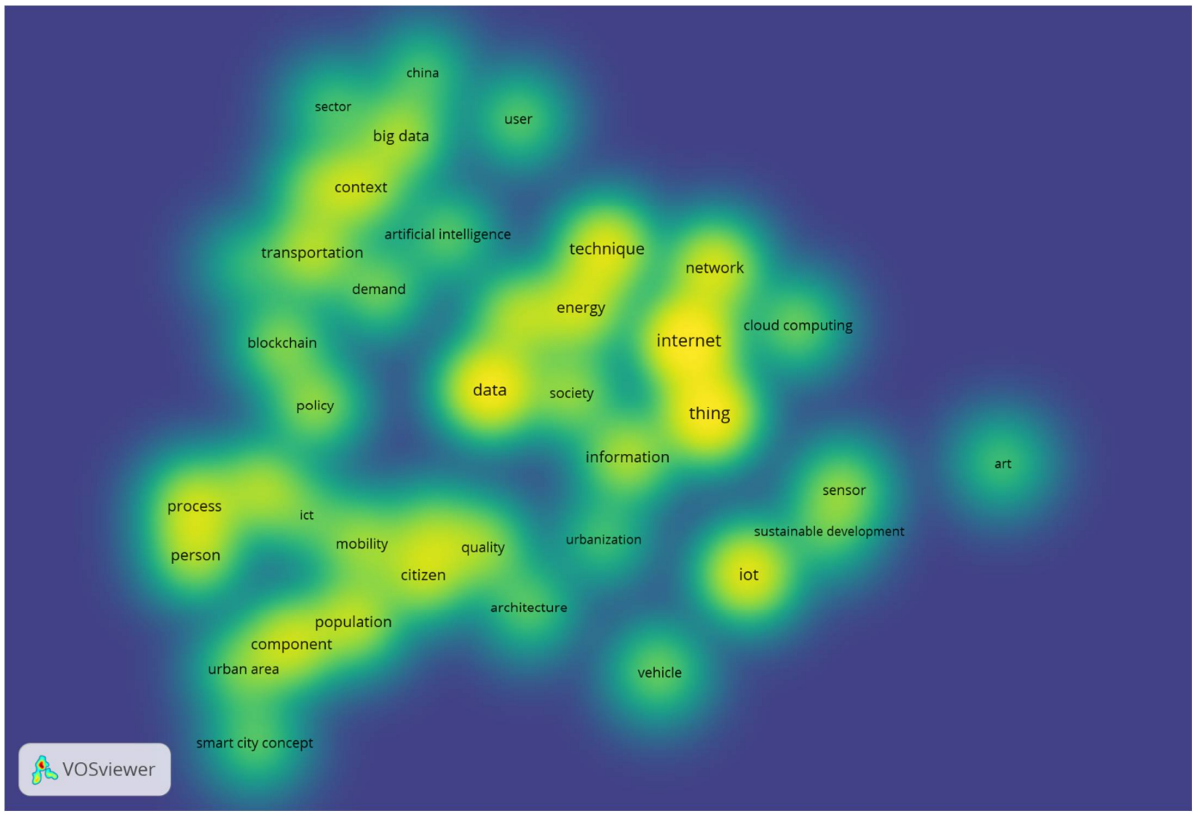

Figure 3. The output of the term co-occurrence analysis for the whole smart city + trend topic, performed in VOSviewer. Density visualization. The figure shows the density of terms present in titles and abstracts of the literature analyzed, providing clusters of networks of co-occurring terms.

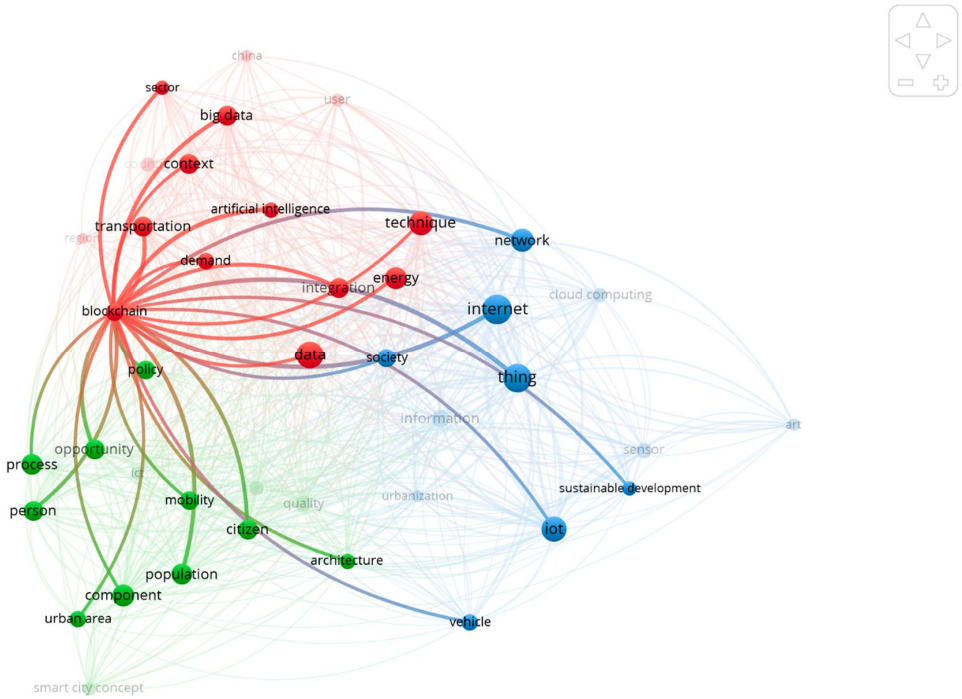

Figure 4. A detail of the network map created in VOSviewer for the query including both smart city and trend as keywords. The image was performed in VOSviewer. It shows the specific correlations of the blockchain word.

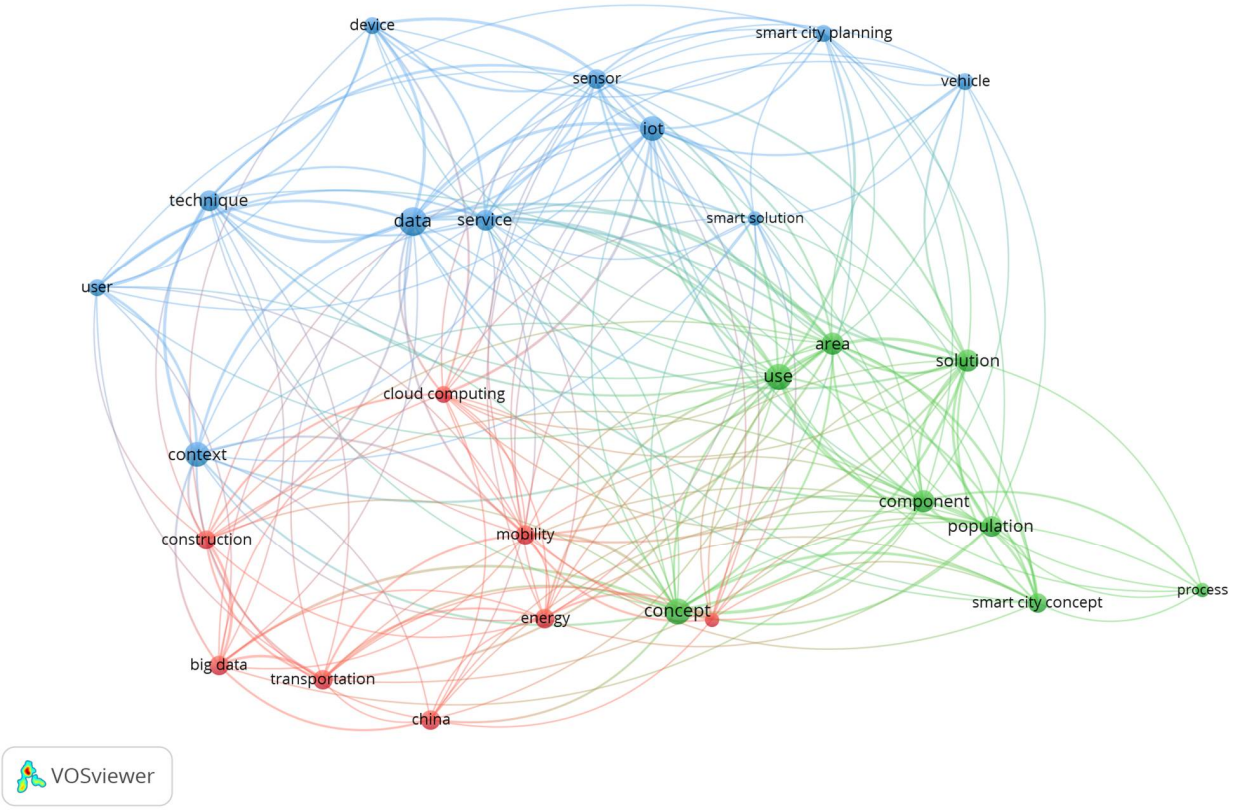

Figure 5. The output of the term co-occurrence analysis for the smart city + trend topic in the 2017–2019 timeframe, performed in VOSviewer. The figure shows the physical distances among terms present in titles and abstracts of the literature analyzed, providing clusters of networks of co-occurring terms.

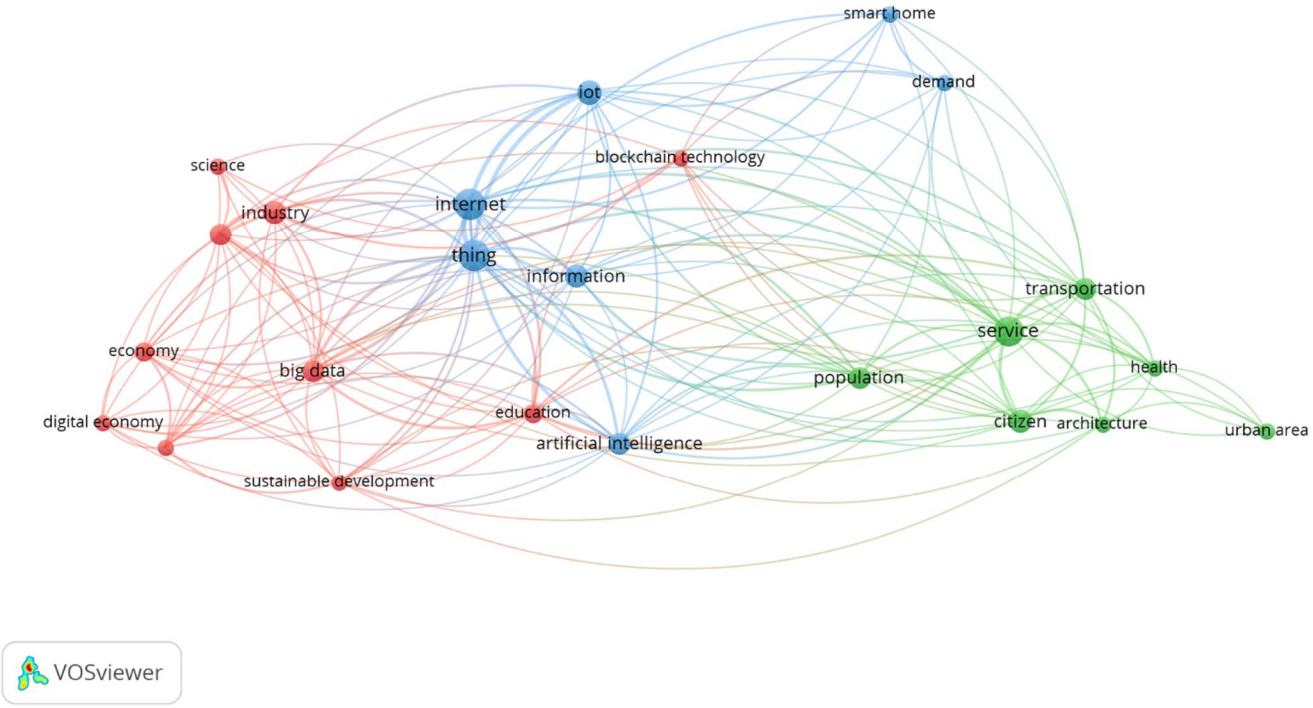

Figure 6. The output of the term co-occurrence analysis for the whole smart city + trend topic in the 2020–2022 timeframe, performed in VOSviewer. The figure shows the physical distances among terms present in titles and abstracts of the literature analyzed, providing clusters of networks of co-occurring terms.

The second cluster is the green one. This cluster collects words related to the smart city concept and to some of the sectors of application. Being in the phase of intercepting the main trends, as reported in the literature, some words can be highlighted: "policy", "mobility", "process", "urban areas", "populations", and "component". The words "policy" and "mobility" are two important sectors in which the smart city seems to be highly present. As reported by [50], the energy and mobility sectors seem to be the most promising ones, especially in terms of future investments and potentialities of improvement in the next years. In addition, the word "process" is relevant, as it shows that many authors agree with the fact that the smart city is a more dynamic process rather than a static project. This is reported in many contributions—see for instance [80–82]. "Urban areas" and "population" are also quite relevant, especially because it seems agreed that the smart city happens especially in urban contexts and that there is a strict relation with citizens and the population in general. However, some contributions also reflect on the potential of considering bigger territories as diffuse smart cities, as what happens in [25].

The third cluster is the blue one. It is related to the Internet of Things (IoT), which is connected to words such as "sensor". This is not surprising, as the IoT can be considered as one of the first fields within which the smart city is often referred to as the main trend of smart city development. However, it appears to also be linked with terms such as "urbanization", "sensors" and "vehicle". In this analysis, a specific cluster on monitoring and physical variables seem to not be present, as had happened in the previous analysis.

In relation to the two timeframes 2017–2019 and 2020–2022 (before and after the COVID-19 pandemic, Figures 5 and 6), it is possible to pinpoint some recurring elements but also some differences. Before going into the analysis of results, it is important to underline that the limited number of contributions present in the two timeframes cannot provide a definitive vision or a full understanding of the phenomenon, but only some preliminary considerations; this is also due to the fact that the pandemic is still ongoing. However, considerations related to this time span and this topic have the potential in supporting further work.

In the two maps, the recurring terms seem in line with the general trends previously identified and without groundbreaking modifications in the two timeframes (Figures 5 and 6), with some limited exceptions. It seems that there has not been a groundbreaking evolution after the pandemic. This is not surprising, as we are not completely out of the pandemic, and more time is probably needed to see the effects on research. However, the two graphs show some limited differences that can be analyzed.

Both analyses report the same three categories: the red cluster related to big data and linked sectors (e.g., transportation and energy); the blue cluster referring to IoT, sensors and devices; and the green cluster referring to the smart city concepts and to the implementation of projects in urban areas.

In the 2017–2019 timeframe, the diffusion of the terms seems quite homogeneous, and there is no clear predominance of one or some words. Contrarily, in the 2020–2022 timeframe, there are some bigger and more evident poles: "service", "internet", and "thing", showing a higher distance with the other words. It seems that in the period after the pandemic, there is slightly stronger attention to these elements than to the others, especially to the service aspects of smart cities implementation.

In relation to the clusters:

- Red cluster. This is the most populated cluster in the 2020–2022 timeframe. It is mainly composed of words referring to big data but also to some specific linked sectors, such as energy, transportation, mobility, and construction. In the 2017–2019 timeframe, it seems more balanced and bounded, while in 2020–2022, there is the word "blockchain" that appears and creates more linkages with the other clusters. In the 2017–2019 timeframe, the dimension of the words is homogeneous, while in 2020–2022, there is the predominance of "policy", "industry" and "big data".
- Blue cluster. It is the most populated in the 2017–2019 timeframe, and it is also quite spread out, having multiple connections with many other terms. It refers to the Internet of Things field of study, including terms related to sensors, devices and to more general words such as "smart city solutions", "smart city planning" and "vehicles". In 2020–2022, it seems to be a stronger concentration on the Internet of Thing precise words.
- Green cluster. It is the least populated in both timeframes, but in 2020–2022, it has the same term number as the blue one. In both clusters, it includes words referring to the application and implementation of solutions. There is an evident "service" term, meaning that it is possible that during and after the pandemic, this topic of research was more considered. This is confirmed by many publications focusing on the impact and the role that new digital services had during the pandemic worldwide.

The growing presence of some terms, such as for example the blockchain domain, is also confirmed in the post-pandemic period by different papers [76–79,83], which identify it as a growing technology useful for cities.

A counting of papers and their subdivision into themes was also performed and evidenced in Table 2. This counting supports further reflections. The first one is the identification of seven themes:

1. Publications about case studies and cities' implementation publications;
2. Specific publications about the blockchain technology that aims to link this solution to the smart city concept;
3. Bibliometric and scientometric analysis;
4. Publications focusing on specific sectors of the smart city (e.g., mobility, energy and so on);
5. IoT, machine-learning, deep-learning, augmented reality publications;
6. Cyber–physical systems and metaverse publications.

Table 2. Recurrent themes in the two selected timeframes (smart city + trend query).

Recurrent Themes in the Two Timeframes (Trends)	2017–2019		2020–2022	
Case studies and cities' implementation	8	20.5%	1	2.8%
Blockchain technology and smart city	1	2.6%	5	13.9%
Digital twin, BIM and smart city	1	2.6%	1	2.8%
Bibliometric analysis and trends analysis	8	20.5%	12	33.3%
Specific sectors or services of the smart city	17	43.6%	12	33.3%
IoT, machine learning, deep learning, augmented reality	4	10.3%	4	11.1%
Cyber–physical systems, metaverse	0	0	1	2.8%
TOTAL	39	100%	36	100%

These themes can be identified as interesting trends to which the smart city discourse seems to converge in the recent scientific contributions.

The second reflection is that there is a decrease in the papers focusing on specific case studies in the 2020–2022 timeframe. These totaled eight in the previous three years (2017–2019) and were reduced to just one in the following.

Thirdly, blockchain technology-related papers are growing in the last timeframe. Bibliometric and conceptual analyses on trends seem to be growing. Finally, publications related to specific smart city sectors seem stable as well as the IoT-related ones. These are preliminary considerations since the limited amount of publications resulting in the WoS for this query does not provide a definitive reading.

4.3. Qualitative Analysis of Recent Smart City Roadmaps Contributions in the Selected Timeframes

The analysis illustrated above concerned the distribution of terms and the recurring themes in publications as reported in recent publications about trends. The following sub-section aims to verify the most considered aspects in roadmap-related contributions that recure the most, both in general and in the two selected timeframes. Due to the limited number of results within this query, a VOS viewer analysis was not possible, as the results were not representative. Thus, the results of this part are not reported in the paper because they are not relevant.

All papers were read in depth, and a more qualitative analysis was provided in this section. Table 3, in particular, shows an analysis of some recurrent themes of the totality of papers selected under the query, searching both "smart city" and "roadmap".

Table 3. Recurrent themes in the entire timeframe (smart city + roadmap query).

Recurrent Themes in the Two Timeframes (Roadmap)	n°	%
Blockchain-related roadmap	1	5.6%
Service implementation roadmap	1	5.6%
Case study specific roadmap	1	5.6%
Integrated service–device–technology roadmap	4	22.2%
Conceptual reflections and critics to smart city roadmaps and frameworks	4	22.2%
Smart city specific sectors related roadmap	4	22.2%
Big data, IoT-related roadmap	3	16.7%
TOTAL	18	100%

Even if the literature specifically focusing on smart cities can be considered as a niche, some publications are present and need to be taken into consideration for their relevance. As it is possible to see in the table, different roadmaps align to different smart city trends, recalling the subdivision provided in Section 4.2.

In addition, there are many typologies of roadmaps, which can be divided into two main types:

- Roadmaps composed of general steps and reflections do not follow a specific methodology and propose variable frameworks and implementation paths;

- Proper technology roadmaps borrowed from the manufacturing field [84]. These are more structured and include more precise and specific paths and orders for implementing tools in cities.

These two typologies align to some trends, as previously identified. These trends are the following:

- Roadmaps linking blockchain technology to cities or in general to the built environment [83,85];
- Technology roadmaps providing a holistic overview of implementation including services, devices and technologies [86–92];
- Roadmaps specifically focused on IoT and big data [93–95];
- Roadmaps of specific case studies [86,96]
- Roadmaps related to specific smart city sectors [85,88,91,97].

In addition to the two roadmap typologies identified, a third group of publications are focused on critics and conceptual reflections on smart cities frameworks and roadmaps.

Table 4 shows some more in-depth analysis related to the two selected timeframes.

Table 4. Recurrent themes in the two selected timeframes (smart city + roadmap query).

Recurrent Themes in the Two Timeframes (Roadmap)	2017–2019		2020–2022	
Blockchain-related roadmap	0	-	1	20%
Service implementation roadmap	1	12.5%	0	-
Case-study-specific roadmap	0	-	0	-
Integrated service–device–technology roadmap	1	12.5%	0	-
Smart city roadmap	2	25%	1	20%
Smart-city-specific sectors-related roadmap	1	12.5%	3	60%
Big data, IoT-related roadmap	3	37.5%	0	-
TOTAL	8	100%	5	100%

The results reported in Table 4 show that the topic of the smart city roadmap is not yet a prominent one. Few papers have been published recently using these keywords. This can be considered a gap in the research literature. Many roadmaps, however, exist but are not produced as scientific contributions but rather as reports of public and private bodies. As reported by Valdez et al. [3], there is no convergence in a unique smart city roadmap. Some suggestions are provided in different frameworks, produced by cross-national bodies or research centers and by specific cities. For example, important reference points are provided by ATIS [98], ARUP [99–101], Cisco [102] and for specific case studies, for example, the "Nordic Smart City Roadmap" [103] or the "Roadmap to Become a Smart City" developed for the Government of Catalonia. However, as reported by Valdez et al., those roadmaps and frameworks tend to pose urban questions as an engineering problem, mostly providing answers to technical aspects. This thesis is also supported by Ben Green, in his book, "The Smart enough city" [104]. As described by the authors [3], smart city discourse is usually framed by an efficient narrative, while the success of these types of implementation does not often come from technical fixes but from enhancing urban collaborations and reinforcing already existing elements (i.e., branding, narratives, projects). For them, the smart city roadmap should be designed as a supporting strategy to already in nuce aspects of cities innovation. This publication came out in 2018 and has been cited many times since. In the same years, another interesting publication was produced on smart city roadmap conceptual aspects [105], while others concentrated on services such as key smart city drivers [86] and more on technological-driven paths [92,94,95]. Lu et al. [92], in particular, drafted a proper technological roadmap, drawing form the manufacturing field [84] and identifying main technologies in three layers (sensor, intelligent and integration), and proposed a proper implementation pathway of smart city technologies. In the same direction, the contribution of Park et al. [95] focused on the role of the IoT in technological roadmaps for smart cities.

In the second timeframe, except for a publication that appeared in 2021 and focused on a technological roadmap for medicine (specific sector) [88], four publications were recorded in the WoS database in 2022. Three of them focused on two core digital innovations, blockchain and building information modeling (BIM), while one was focused on conceptual and governance-enabling aspects [106].

Pereira and Azambuja [106] argued that smart cities still need improvement in the governance sector. According to them, there is a need to first enable key governance conditions in order to enable, with a cascading effect, other types of innovation in cities. The roadmap they proposed is composed of three phases and eleven governance conditions. Jiang et al. [90] discovered in the building information modeling a key driver supported by government or industry. In their comparative study of BIM implementation in three cases in Singapore, the United Kingdom and the United States, they detected different types of technological-based implementation roadmaps. The two contributions on the blockchain mainly referred to specific sectors. The contribution provided by Akinradewo et al. [83] consists of a literature review on blockchain technology applied to the built environment and supported the idea of the blockchain as a potential future driver of smart cities, as also argued by Bhushan et al. [78].

5. Discussion

This paper aimed at supporting studies on the smart city concept, providing small advancements on the topic and trying to understand if the COVID-19 pandemic has influenced the research field and eventually how. In addition, the paper aimed at checking two specific niches of the literature production, namely, contributions focusing on trends and drivers as well as contributions focusing on roadmaps (both technological and not). WoS was queried with both "roadmap" and "trend" wordings in association with "Smart City". To conduct this analysis, both a qualitative and a bibliometric analysis were performed using the Web of Science database and the tools VOSviewer. Some interesting points were evidenced in the results as new findings and will be recalled here, in relation to the research questions.

RQ1: Is it possible to see some evolutions or changes in smart city trends before and after the COVID-19 pandemic?

The answer to this question, according to the analysis performed, is positive. There have been some small modifications, but it is not clear whether these were due to the COVID-19 pandemic. More distance in time is probably needed to identify potential changes. In this review article, it is only possible to detect some elements of attention that should be confirmed by future research.

The majority of bibliometric analyses consulted by the author confirm the presence of three main topics around which the debate on the smart city seems to converge: big-data, IoT and theoretical research, with the addition of a fourth topic, identified in monitoring and sensors. After the pandemic, in the 2020–2022 timeframe, it is possible to detect growing attention to specific aspects of the smart city: services, policies and IoT.

Some specific technological innovations seem to have received growing attention in their connection with the smart city, such as the blockchain and the metaverse, but also BIM and digital twins. The number of publications around specific smart city sectors and specific case studies is quite present as well, but is more stable, while bibliometric and systematic review contributions are growing.

RQ2: Are roadmaps and pathways linked with the smart-city-related scientific production? Is there an increase in attention to these types of publication after the COVID-19 pandemic?

The presence of publications focusing on smart city roadmaps can be considered an interesting niche in the smart city scientific production. This is, however, an interesting aspect of the literature, as many frameworks and roadmaps exist, but they are produced by public and private bodies with many purposes (namely, political and economic ones). The scientific community seems less interested in these types of contributions even if some are present, mainly related to specific case studies or sectors. A growing number of technological pathways are however present, providing a technological-centered approach

to the topic. Regarding the COVID-19 pandemic, the amount of analyzed papers is not sufficient to precisely detect correlated changes. An enlargement of the base of literature is needed to follow this question. However, only in 2022 and considering the WoS database, have four publications been produced, while in previous years, there were less. Only in 2018 were there five roadmap-related publications, followed by two in 2019, one in 2020 and one in 2017.

6. Conclusions

In conclusion, this review has highlighted some interesting aspects of the smart city concept and has drafted potential new lines of research, which could be deepened in the future. The methodology used has been twofold, providing, on the one hand, a qualitative review of recent contributions on the smart city topic and on related roadmaps and, on the other hand, bibliometric analysis within the VOSviewer tool. The contribution identified some literature gaps that can be covered in the next few years and has raised some questions that could frame future reviews. The main raised aspects are the following:

1. Smart city discourse seems to have achieved a stability in its declinations. Even in the richness of positions and in the absence of a definitive and shared definition, the topic seems to be framed, for some years now, by three core aspects: IoT, big data and theoretical discussions that include different sectors of application, multiple implemented case studies and citizen-related aspects. Some growing aspects are identified into the sensor and monitoring science, including air quality and smart devices.
2. Growing attention seems to be put into specific technologies that can see in the next years an increased application in smart city projects. The more promising one seems to be the blockchains, followed by building information modeling and metaverse or cyber–physical space.
3. The COVID-19 pandemic may have produced a concentration of the scientific attention to some specific aspects, such as the development of services and their role during the pandemic and more in general the IoT application into cities. However, more in-depth and extensive research is needed to verify this hypothesis.

The implications of this study mainly rely on confirming and highlighting some current trends of smart city development, especially inside the scientific debate, and opening new hypotheses to be verified in further research.

The main limitation lies in the limited amount of contributions present in WoS for the "roadmap"-specific keywords, which could not perform a relevant bibliometric analysis. In addition, the pandemic is too close to observe sensible impacts on scientific production.

Further works will concern an enlargement of the literature base, also querying the Scopus database with the same wordings to check if there is a bigger body of literature that either confirms or alters the reflections provided in this contribution. The inclusion of a more direct pandemic-related wording can support this search. In addition, a quali-quantitative analysis will be made on smart city trends and roadmaps at the forefront of the new European Recovery Plan, which is supporting city transitions, while also empowering actions on smart-city-related issues. Some reflections are expected to be produced in light of the new funding for cities that has been made available within this European strategy.

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