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Article

How the V4 Nations Handle the Idea of Smart Cities

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Abstract: Smart city is a term that includes digital, information, and communication technologies that contribute to increasing the level and quality of life in individual cities. It focuses primarily on the efficient use of existing resources but also on the discovery of new ones, with the goal of lowering energy consumption while also reducing environmental impact and optimizing traffic in specific areas of the city. This concept is increasingly coming to the fore. Thus, the aim of this article was to determine the level of involvement of Slovak, Czech, Polish, and Hungarian authors in solutions for Smart cities using Web of Science data. The analysis of countries that form the Visegrad Four (V4) region reveals how the region ranks compared to other countries that are actively involved in Smart cities based on VosViewer. To map a specific region of countries, it is necessary to first understand the underlying causes of the problem worldwide. Then, the status of the authors, the number of articles and citations, and universities may be actively discussed and graphically depicted for each nation in Visegrad. Based on the discovered results, academics can identify the contributors and institutions that have solved the issue individually or in co-authorships over a long period. The findings provide data for future testing of selected dependencies and a platform for creating a scientific model to rank countries. In addition, the authorities may focus on identified clusters of key areas that are an essential part of Smart cities and provide a higher quality of life in their city for the people.

Keywords: bibliographic analysis; smart city; Visegrad Four

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1. Introduction

Rich and developed nations have made enormous investments in innovation and research during the Industry 4.0 era [1,2]. This includes the requirement for new concepts that call for the use of sustainable and smart technologies and processes [3–5]. These incentives cover a wide range of industries, from smart manufacturing to smart homes and smart buildings, ending with the integration of smart cities [6–8]. Smart, creative, inventive, and sustainable cities necessitate advanced planning and technologies, as well as creativity and smart governance [9–11].

The ancient civilizations of Egypt, Greece, and Rome are a good illustration of how everything was organized such that it may be now discussed in the context of "smart cities". The Romans were unmatched builders who mastered a wide range of trades that helped to create the modern world. They were the first people to build long highways with well-planned crossroads, breaks, and rest areas. This helped make sure that the route was used often, had enough supplies, and was safe. Like how the entire city of Rome, which at the time was the most intriguing metropolis in the ancient world, was planned. The ancient Romans taught others who oversaw the growth and building of cities around the world. It is a highly difficult job since workers must evaluate a variety of scenarios that might still occur in a particular city or plan for the possibility that the city could alter, rebuild, or grow in the future. These personnel must accomplish all these goals for the city to function independently and cohesively. Because of this, the term "smart city" was

first used in 1991 by Drohojowska [12]. Researchers are becoming more and more aware of Smart cities at this point, although the first significant interest in the subject may be noticed in 2011 (Figure 1).

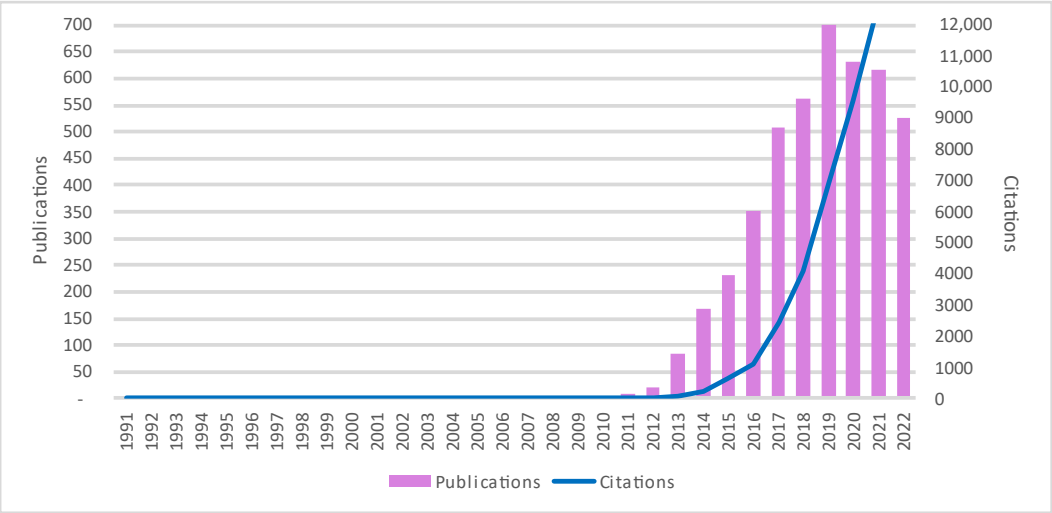

Figure 1. An overview of publications and citations on the topic of Smart cities. Source: own analysis as per Web of Science (2022).

Recent studies deal with many aspects of Smart cities: smart mobility, smart living, smart environments, smart citizens, smart software, smart sensors, and the development of smart architecture [13–16]. The meaning of the term "Smart cities" has evolved throughout time [17,18]. Currently, Smart cities and regions could be defined as those that use data, information, and communication technologies and engagement (i.e., the involvement of a wide range of interested parties in decision-making) as tools for achieving goals that help save money and material resources, provide better, more convenient, and efficient public services, and help achieve measurable indicators at the city or regional level [19–21]. This paper focuses on the Slovak, Czech, Polish, and Hungarian environments that form the V4 region. To map a specific region of countries, it is necessary to understand the underlying causes of the problem worldwide. Using bibliometric analysis, this paper first summarizes a specific key issue of Smart cities in general.

Academics confirm that implementation of the concept of Smart cities benefits the city, the region connected to the city, and the whole country [22,23]. Firstly, studies dealing with the issues of specific cities were introduced, followed by studies for individual countries.

Thus, many cities across the globe have adopted the smart idea and have either developed their infrastructure to achieve this new status, or are actively looking for ways to adapt their current assets and networks. London, New York, Paris, Amsterdam, Reykjavik, Tokyo, Busan, Dubai, Stockholm, and Santander are among them [24,25]. The reasons for the real usefulness of Smart city initiatives are that sustainable urban development planning calls for an all-encompassing strategy that incorporates cooperation and coordination among various levels of government, businesses, and society [26–28]. An important part of the solution of Smart cities is not only to focus on cities globally, but it is also important to design each city in such a way that each tool is applied precisely to it, as each city is unique, as evidenced by, for example, different historical events and preserved historical cores of cities. Modern cities are no longer proud of such a space, so it is important to accurately prepare governance for individual parts of cities [29–33]. For example, Alablani and Alenazi [34] create planning for Smart cities for Manhattan. Niccolai [35] has made proposals to improve the quality of streets in France. Gea et al. [36] map Barcelona in detail.

The authors from the Visegrad Four also focused on case studies of the cities themselves. For example, Rohlena and Frkova [37] create a concept for Prague; Svitek et al. [38] expands this concept. The project of cross-border tourism between Usti nad Labem and

Dresden was addressed by Novotny [39]. The problems of the city of Brno have had solutions offered by Pavlovsky [40]. Muzik et al. [41] focused on the city of Pilsen. Studies were developed for the Zlin region [42], Bratislava [43], Kosice [44], Poprad [45], for cities in Poland [46], Krakow [47], Bydgoszcz and Rzeszow [48], the Swietokrzyskie region [49], Zielona Gora [50], Poznan [51], Wroclaw [52], and for the city of Bydgoszcz [53]. Szaszak and Kecskes [54] contributed to the development of the study for Hungarian Smart cities. Specifically, Lengyel et al. [55] applied this concept to the city of Segedin.

Smart cities are a priority of projects co-funded by the European Union and the government of the V4 region. However, the calls to reduce disparities in the levels of development, growth, and quality of life in and across Europe's regions, as well the calls of individual governments, are oriented not toward individual case studies but rather toward research that assesses whole countries or regions of countries.

The following smart city solutions were delivered for countries outside of Europe: Yu and Xu [56] provide an empirical analysis of the development of Smart cities in China, where this topic is considered a hot one. Mahizhan [57]; Hin and Subramaniam [58] focus on experiences in Singapore. Lim et al. [59] note an increase in quality through the implementation of Smart cities in South Korea. Shruti et al. [60] monitor Smart cities in India. Sidani et al. [61] offer a comparative study between Malaysia and Italy. Lim and Yigitcanlar [62] focus on only Malaysia. Mendybayev [63] evaluates the issue in Kazakhstan. Mboup and Oyelaran-Oyeyinka [64] assess the concept of the Smart city in Africa. Maalsen et al. [65] extend it to Australia. A study in North America was carried out by Aldama-Nalda et al. [66].

Caragliu et al. [67]; Lowe [68] pay attention to Smart cities and their governance in selected European countries. Specifically, Davies et al. [69] highlight creating smart functioning and infrastructure for individual country. Kupriyanovsky et al. [70]. and Chapman [71] look at sustainable development in Great Britain. Siokas and Tsakanikas [72] consider Smart cities and municipalities in Greece. Dudzeviciute et al. [73] look at the issue in Lithuania and Sweden. Pihlajamaa and Merisalo [74] analyze the situation in Finland. Smart cities in Norway are identified by Berntzen and Johannessen [75]. Sergi [76] describes Smart cities and their development in Russia. There is an absence of similar exploration in V4 nations.

Authorities, as previously stated, have been requiring a focus on smart cities in the V4 region. But the providing of comprehensive study of this issue by Slovak, Czech, Polish, and Hungarian researchers individually or in co-authorships has been underrated. Thus, the aim was to determine the level of involvement of V4 countries in solutions for Smart cities using Web of Science data.

The article was organized as follows: Firstly, the theoretical foundations of Smart cities are introduced, supported by recent global studies. Then, the materials and methods employed in the provided study are demonstrated. The Section 3 includes our findings and discussion. The study is summarized in the conclusions, which also provides constraints and suggestions for future ways of exploration.

2. Materials and Methods

Long-term research has been conducted to prepare for the smart cities issue in the V4 countries. It consists of three phases:

A. Initial phase

The first phase included a quantitative literature review. It is focused on ProQuest, Scopus, and the Web of Science, based on the exploration by Beckett [77].

B. Second phase

The academic productivity of leaders has been shown to have a positive influence on the research performance of their specific research field [78]. Thus, this phase tests the dependence between the number of authors of a publication, its citations, and the impact factor of the publishing journal, based on the study by Ciriaco and D'Angelo [79]. This

step also creates a scientometric model of scientific output to rank countries. Krajcsak [80] provides methodology that will be modified for a future model in the issue of Smart cities.

C. Final phase

A new and essential technology for digital transformation and intelligent updating is the digital twin. The digital twin can conduct monitoring, modelling, prediction, and optimization tasks when driven by data and a model [81]. The last purpose of the research is to put forward digital twin modelling for Smart cities. The planned approaches are oriented toward monitoring and sensing technologies [82], urban sensing technologies in immersive 3D environments [83], wireless sensor networks [84], digital twin algorithms [85], and data mining algorithms [86].

This study analyzes Smart cities in V4 nations, and positions itself as the initial phase of the mentioned long-term research. A new and essential technology for digital transformation and intelligent updating is the digital twin. The digital twin can conduct monitoring, modelling, prediction, and optimization tasks when driven by data and a model [81]. The last purpose of the research is to put forward digital twin modelling for Smart cities. The planned approaches are oriented toward monitoring and sensing technologies [82], urban sensing technologies in immersive 3D environments [83], wireless sensor networks [84], digital twin algorithms [85], and data mining algorithms [86]. Figure 2 involves methodological steps that were used. Each step was described to the possibility of replicating the study.

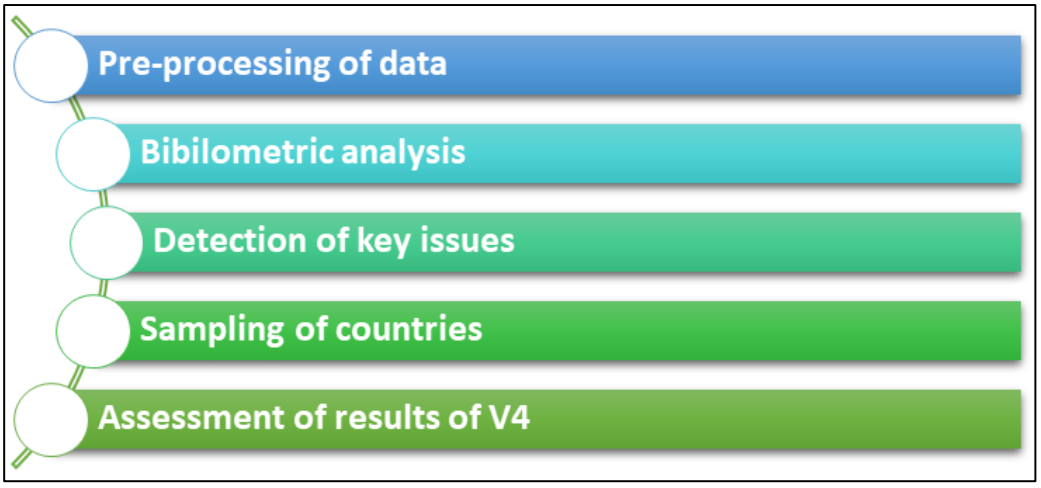

Figure 2. The methodological steps of the study. Source: own processing.

1. Pre-processing of data

To prepare the article, it used the data available in a specific scientific database. Tripathi et al. [87] recommend this approach based on secondary data from Web of Science. On this page, it focused on articles that were written on the topic of Smart cities. This term appeared in more than 4800 articles, the largest part of which was articles, with more than 2400 articles, followed by proceeding paper, which has more than 1790 articles, and editorial material, which completes the trio with 335 articles. Other document types had lower occurrences. The review by Camero and Alba [88] served as the foundational argument from scientific literature to use a number of publications for the issue of Smart cities.

2. Bibliometric analysis

The VosViewer software was chosen to evaluate data from the Web of Science database. The recommendation to create a bibliometric analysis was obtained by following studies from very similar or equal issues. Kostrzewski and Melnik [89] monitor transport systems via this analysis. Qiang et al. [90] deal with the mapping of network studies of public opinion. Guo et al. [91] created research on bibliometric analysis of Smart cities research.

Winkowska et al. [92] address the concept of a smart city in the context of a literature review. Zhao et al. [93] create a knowledge domain map of smart city research. Hajek et al. [94] analyze the latest developments in the evaluation of Smart cities based on the creation of a literature review, which they transformed through bibliometric and content analysis. Kousis and Tjortjis [95] focus on data mining algorithms for smart cities. Mora et al. [96] conduct bibliometric analysis to evaluate the first two decades of Smart city research. Bajdor and Starostka-Patyk [97] supplement conceptual dimensions and areas by means of bibliometric analysis. Parlina et al. [98] prepare a cluster of states in Indonesia that address the issue of Smart cities. Sharifi et al. [99] produce three decades of Smart city research. Perez et al. [100] and Rejeb et al. [101] map blockchain technology in Smart cities. Vujkovic et al. [102] provide a research analysis of smart public governance, in the sense of Smart cities. Comparing previous studies, the article delivered an analysis of the unique period of years 1985–2022, which cover the whole publication era of the Smart cities issue in the Web of Science. Table 1 involves all information for analysis made.

Table 1. Steps of bibliometric analysis.

Topic	Years	Database	Number of Articles	Analysis	Software
Smart cities	1985–2022	Web of Science	>25,500	Bibliometric	VosViewer

Source: own processing.

3. *Detection of key issues*

Among the most serious issues are inconsistencies in the number of publications and the focus of scientific workers in various countries around the world. Based on Web of Science data, the results of cartograph gave an overview of countries dealing with the topic of Smart cities. The top eight countries were identified. The VosViewer was run to create bibliometric analysis of key issues in Smart cities. Key issues involved countries and authors related to the concept of Smart cities. In addition, a bibliometric analysis of keywords was presented.

4. *Sampling of countries*

Based on the findings, it was found that authors from V4 are not very interested in the issue of Smart cities. This was proven by VosViewer detection. Thus, the research focuses on V4 nations, specifically, in the spheres of detection, analysis, problem solving, and subsequent advancement of the concept of Smart cities. The assessment period in these countries was chosen according to the occurrence of given issues in the last decade. But both intensity and interest have had a growing trend for each country in the V4 countries.

5. *Assessment of results of V4*

The aim was to determine the level of involvement of V4 countries in solutions for Smart cities using Web of Science data. To comprehensively deliver the outputs of the article, the analyzed grouping of V4 states was divided into individual states, which were evaluated based on the number of articles produced and the most important authors who are most involved in raising awareness of the given term and by applying Smart cities tools to improve the quality of life of residents in cities. In addition, an overview of the Visegrad institutions that publish the most on the topic of Smart cities was performed. MS Excel was used to make the cartograph, and then also the rest of the graphical representation.

3. Results and Discussion

Firstly, the discussion of Smart cities is not exclusive to any one place, nation, region, or continent based on Figure 3. This shows which nations worldwide write the most articles on a specific topic. The darker the color of the country, the more articles from this area. Scientists, researchers, analysts, development engineers, architects, etc. are working to find

a solution to this issue on a global scale. All these professions work to make sure that cities can reach their full potential and that life is harmonious there.

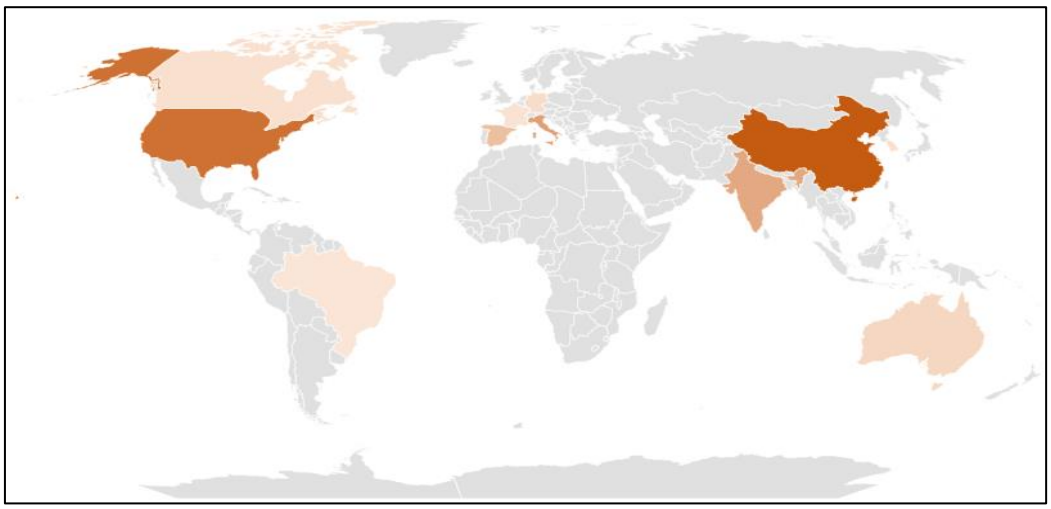

Figure 3. An overview of countries dealing with the topic of Smart cities. Source: own analysis as per Web of Science (2022).

Table 2 shows the top eight countries that deal with the topic of Smart cities based on the Web of Science. Smart cities were received most interest in China with 4090 documents. This was followed by the USA with 3533 documents and Italy with 2432 documents. India covered the issue with 2199 publications. England and Spain provided almost equal numbers of papers (1652 and 1650). The sample was completed by Australia with 1114 contributions, and almost 1000 were delivered by Austrian authors.

Table 2. Top eight countries dealing with the topic of Smart cities.

Rank	Country	Number of Documents
1.	China	4090
2.	USA	3533
3.	Italy	2432
4.	India	2199
5.	England	1652
6.	Spain	1650
7.	Australia	1114
8.	Germany	977

Source: own analysis as per Web of Science (2022).

The VosViewer software was employed for an overview of connections between countries dealing with the topic of Smart cities. Seven clusters were created based on Figure 4. The United States dominates the blue cluster. India is the most important country in the green cluster. Italy plays an important role in this topic for the red cluster. The turquoise cluster is impacted by England. Spain is ruling in the yellow one. China is the main country discussing Smart cities for the orange cluster. Singapore is the largest nation in the purple cluster.

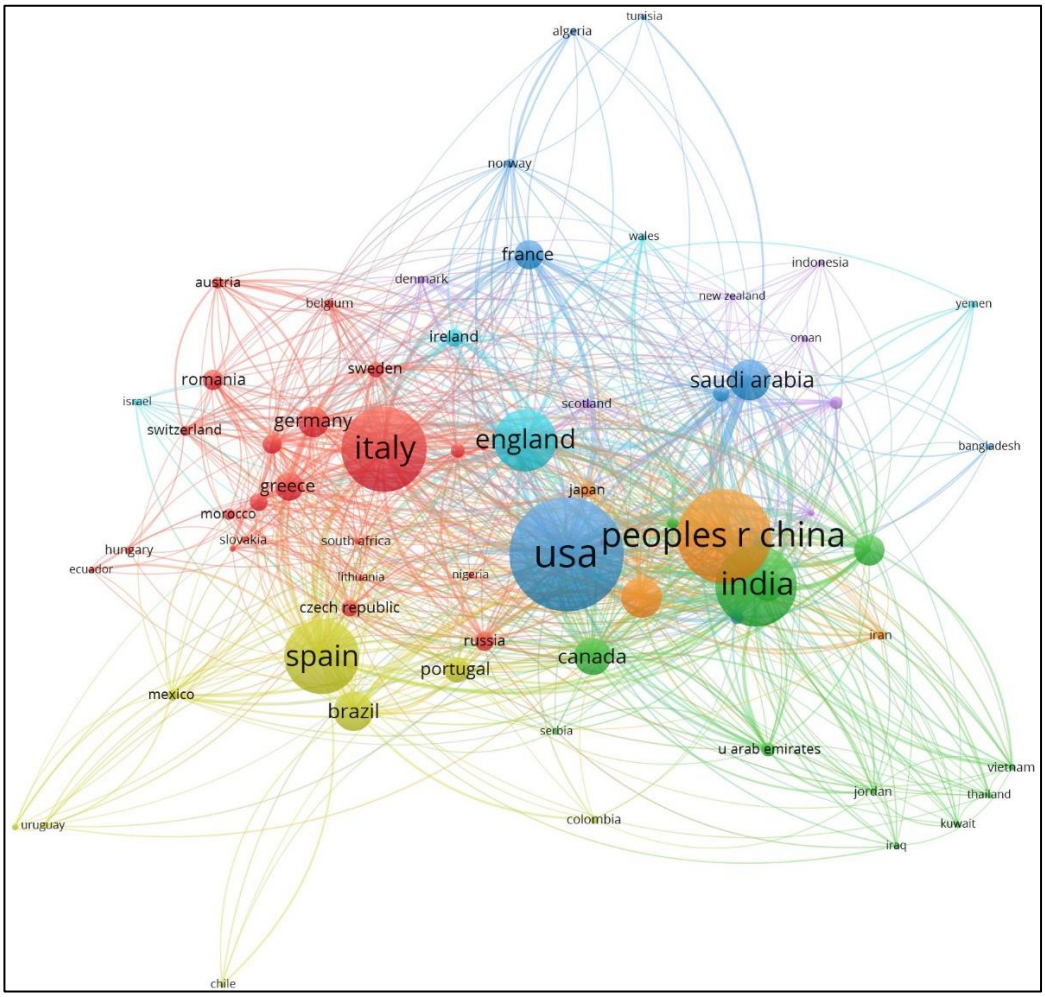

Figure 4. Bibliometric analysis of countries dealing with the topic of Smart cities. Source: own analysis as per Web of Science (2022).

The VosViewer tool was used to discover the authors (clusters and connections) who have had a big influence on the subject. Figure 5 illustrates how the public's knowledge informs the authors who contributed to the topic. There were captured six clusters. Al-Turjman, whose work has drawn the attention of many other scientists, as indicated by the fact that he is the most often published author in the cluster, is undoubtedly one of the writers who significantly contribute to the visibility of the given issue (pale blue color). Guizani is another significant author in the discipline who, like many other authors in the yellow cluster, served as an inspiration. The topic of smart cities also directly involves the author, Kantarci, whose writing propelled other authors to broaden their perspectives (green cluster). Authors in the blue cluster were motivated by Djahel to produce more scientific work. Finally, Lloret was the driving force behind the authors in the red cluster. He is also a significant author in the purple cluster, alongside Kumar, who may be considered Lloret's his representative.

The article's preceding section was devoted to general guidelines and the nations that are largely linked with the idea of smart cities. Which keywords the author should concentrate on while writing a high-quality article are also crucial to ensuring that the given article and any others that follow it and cover the given problem may be accessed by laypeople or junior scientists who are becoming interested in the issue.

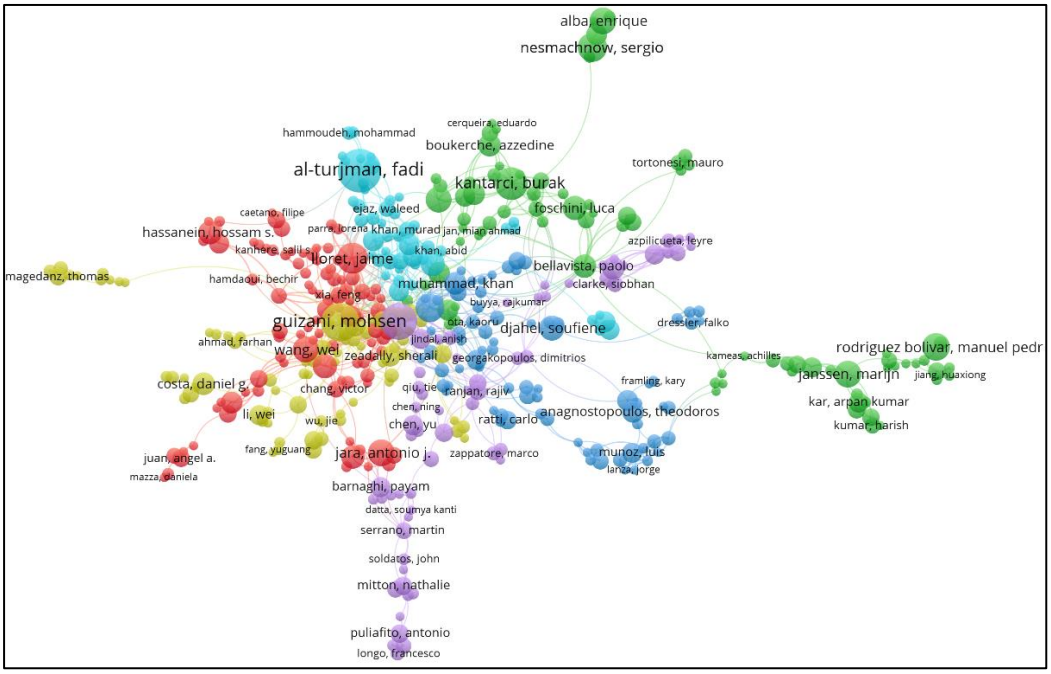

Figure 5. Bibliometric analysis of countries dealing with the topic Smart cities. Source: own analysis as per Web of Science (2022).

Therefore, the bibliometric study also concentrated on the keywords linked with the supplied phrase that were used the most frequently. Figure 6, which was created based on more than 25,000 items discovered on the WoS website, accurately depicts this reality. There were seven clusters.

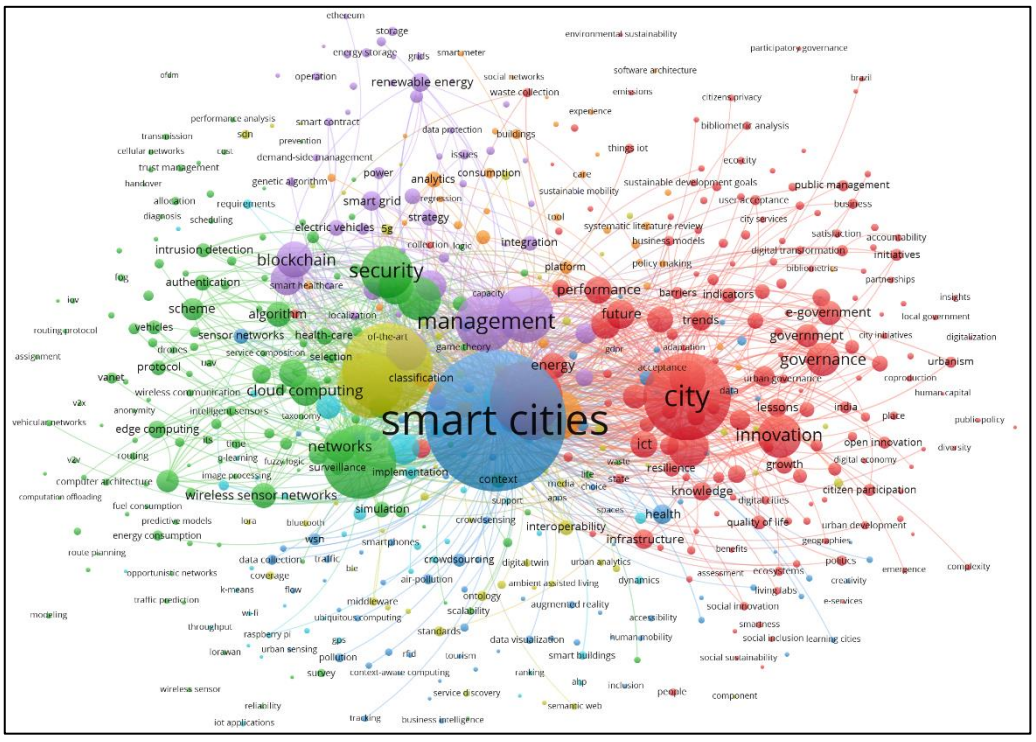

Figure 6. Bibliometric analysis of keywords dealing with the topic Smart cities. Source: own analysis as per Web of Science (2022).

Figure 6 illustrates how the term "Smart cities" is used to refer to not only to cities but also other crucial technologies, pursuits, or fields of study. As we can see, Smart cities (the cluster shown by the blue color) and the word City (the cluster symbolized by the red color), which is the second most represented, have the biggest representations, which is not surprising. After this, we most often encounter words like "management" (cluster represented by the purple color). This phrase is crucial because, as has already been said, a comprehensive planning strategy is one of the most significant instruments that must be used in creating a smart city. When developing a plan, management is given top priority. When a smart city is set up incorrectly, the plan is useless, money is distributed and used inappropriately, and the total benefit is very low. Effective management works to prevent this, and with the right policies in place, the intended outcome — high added value produced at low cost — is achieved. Security is a different idea connected to the idea of a smart city (a cluster represented by the green color). People's safety is related to incorporating a smart city into their lives. Not only must police patrols provide security, but the general configuration of the instruments used to build a smart city must be at a level where "artificial intelligence" (the orange cluster) can cope with it and suggest solutions that are safe for human life and helpful to them. This can be visualized, e.g., as intelligent sensors on traffic lights that assess the volume of traffic on specific roads in the city and send the information to the artificial intelligence headquarters, which then determines how frequently specific traffic lights should be switched in each city to achieve smooth road traffic and make life easier for pedestrians and cyclists who move along roads and may be in danger from motor vehicles. The last cluster (with a light blue color) concentrates on cloud computing, which is the computing server that decides how each artificial intelligence instruction should be entered. It is also a collection of data that experts can use to figure out how to fix a problem or choose which computer equipment to use in different parts of the city to make it less likely that it will happen again.

The V4 nations and V4 region did not achieve a significant position in any of the three bibliometric analyzes performed. Due to this, we assessed V4 generally on the topic of Smart cities. Then, for each country, an in-depth look was taken at the authors, the number of articles, and the number of citations.

The image of the intensity of publication in the Visegrad Four is depicted in Figure 7. The darker the color of the country, the more articles from this area. Specific numbers of documents on the topic of Smart cities are shown in Table 3. Although they are not particularly well represented in the topic at hand, they contribute to making cities' traffic, air, and noise levels better. Poland made the most significant contribution to the problem, providing 481 documents on the subject. Czechia, which had 321 publications that have contributed to a better knowledge of Smart cities and the need to use smart instruments, is in second place. Hungary, which ranked third on the list, contributed 181 papers to enhancing the standard of Smart cities. Slovakia was represented by 118 contributions, claiming last position.

Table 3. The rank of V4 countries in dealing with the topic of Smart cities.

Rank	Country	Number of Documents
1.	Poland	481
2.	Czechia	321
3.	Hungary	181
4.	Slovakia	118

Source: own analysis as per Web of Science (2022).

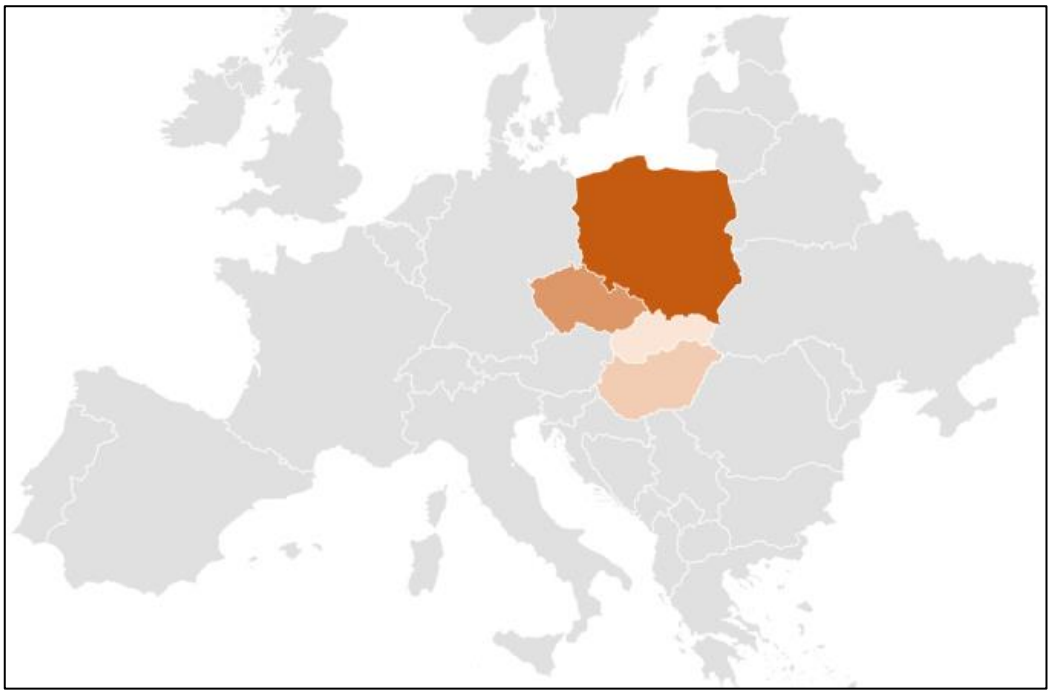

Figure 7. An overview of published articles from V4 countries on the topic Smart cities. Source: own analysis as per Web of Science (2022).

The accompanying citation analysis shows that the idea of smart cities started to be addressed more often in Slovakia in 2014. (Figure 8).

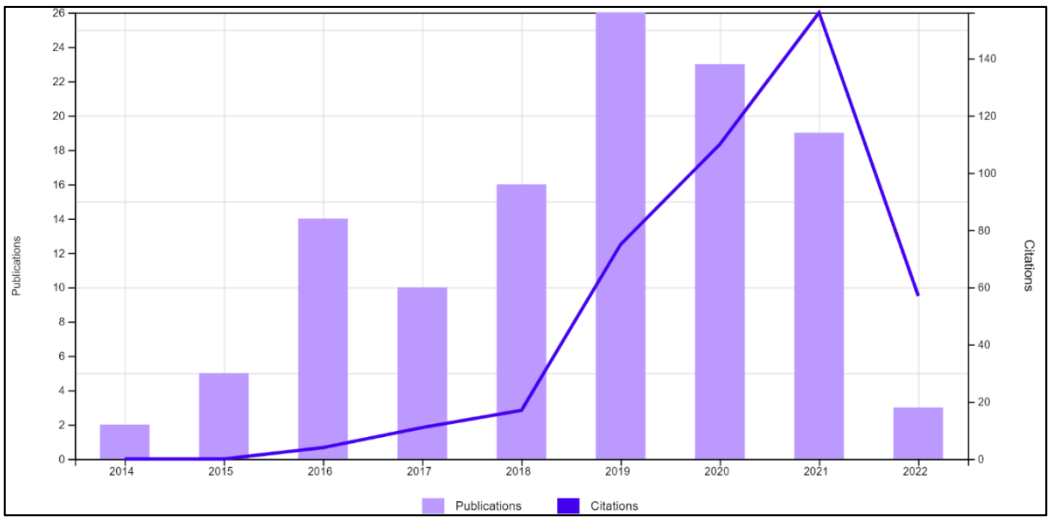

Figure 8. An overview of publications and citations on the topic of Smart cities in Slovakia. Source: own analysis as per Web of Science (2022).

In 2019, during which there were 26 publications, we see the biggest rise in the number of publications. There hasn't been a higher number in any year since 2019 On the other hand, the number of citations, or the number of articles that other authors used to understand the given issue, expand on it, or refute it, reached a respectable 156 in 2021. This means that researchers from Slovakia were the inspiration for up to 156 articles from all over the world.

According to Figure 9, notable authors include Caganova, Kubina, Sulyova, Vodka, Borsekova, etc. They will be incorporated into the model for assessing scientific output in the context of smart cities under V4 conditions.

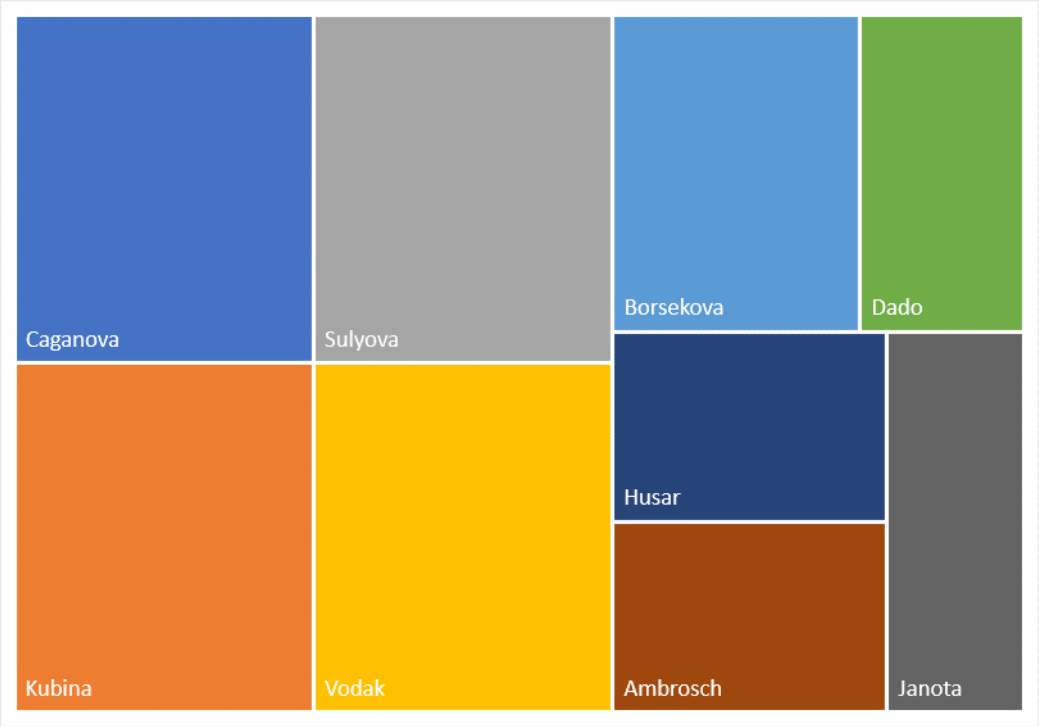

Figure 9. An overview of Slovak authors publishing on the topic of Smart cities. Source: own analysis as per Web of Science (2022).

Since 2014, researchers from Czechia have also begun to use the phrase "Smart cities", as seen in Figure 10. The year with the most publications was 2019, when 30 papers by Czech authors were published. The writers from Czechia received the most citations, up to 240 in 2021, which is a very respectable total by V4 standards. Based on the statistics, they are ranked second among the V4 nations, barely after Poland, which is the clear leader in the publication of articles on the topic of smart cities among the Visegrad Four nations. Of course, this fact is also affected by the population of each city, the total number of cities, and the number of scientists who are qualified to work on the subject at hand.

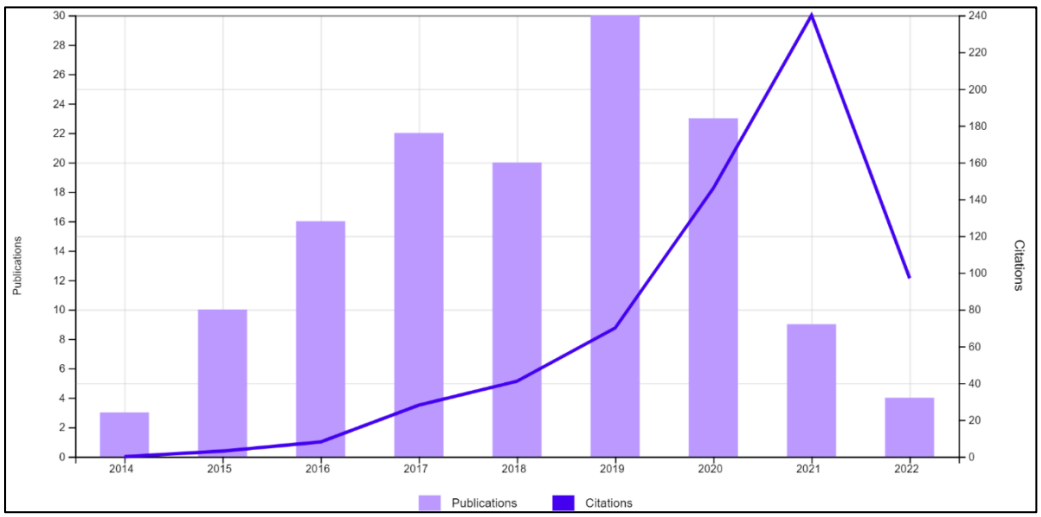

Figure 10. An overview of publications and citations on the topic of Smart cities in Czechia. Source: own analysis as per Web of Science (2022).

The most significant Czech contributors who address the topic of smart cities are Scroll, Added, Quarry, Burner, Tailor, etc. (Figure 11). They will be incorporated into the model for assessing scientific output in the context of smart cities under V4 conditions.

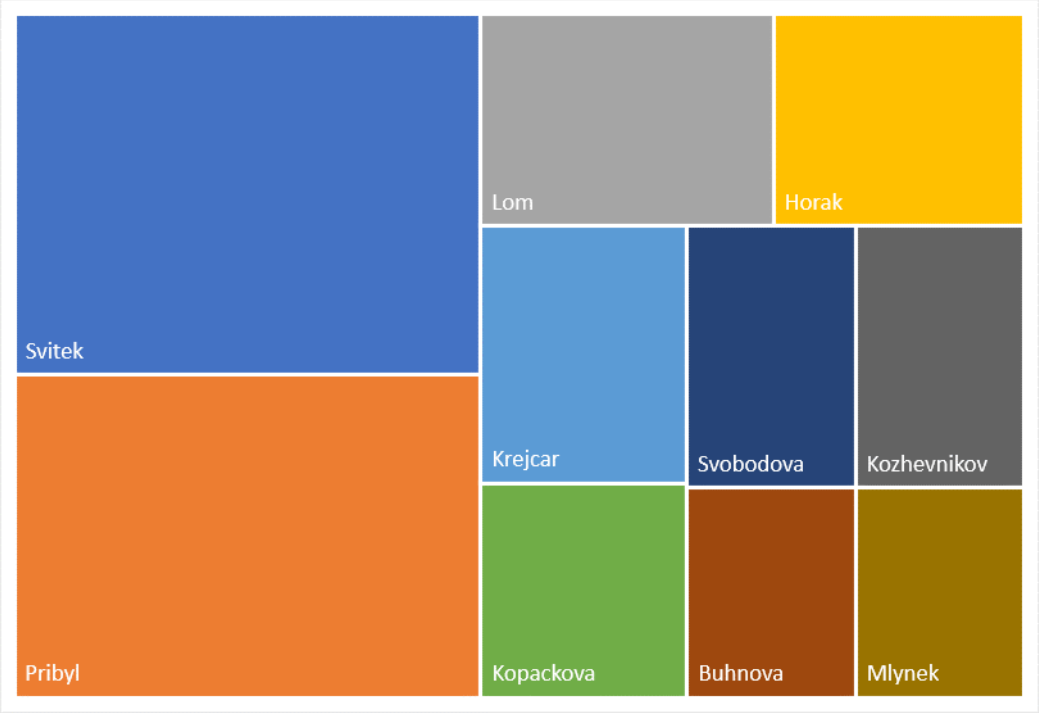

Figure 11. An overview of Czech authors publishing on the topic of Smart cities. Source: own analysis as per Web of Science (2022).

Amongst the Visegrad Four nations, Poland leads in discussing Smart cities. Figure 12 shows an overview of publications and citations on the topic of Smart cities in Poland. The 481 total publications show that Polish researchers were making an effort. The increased number of papers is also attributable to the fact that Polish scientists started to discuss Smart cities in 2013. Poland's scientists were able to create 48 articles in 2021, making that year their most productive in terms of publications. The number of article citations, which totaled 460 that year, also set a record.

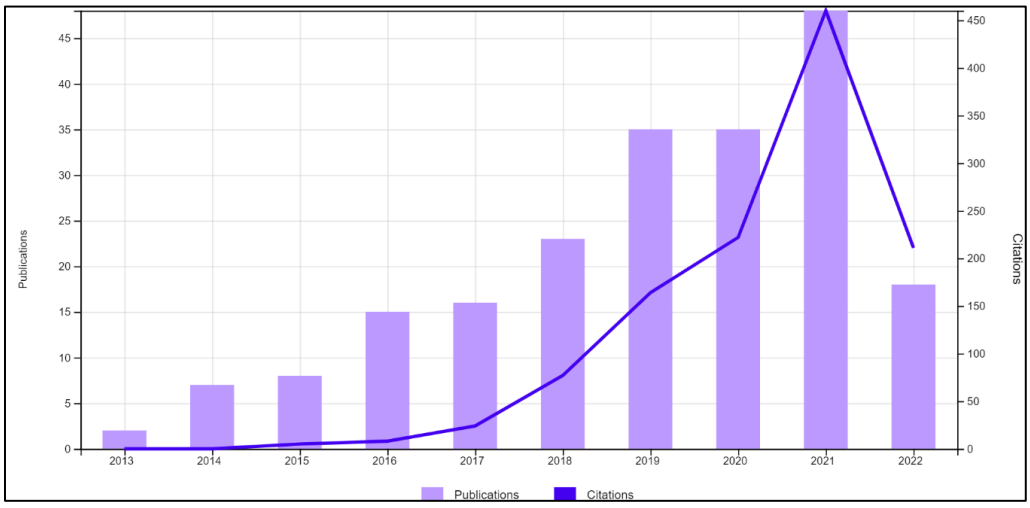

Figure 12. An overview of publications and citations on the topic of Smart cities in Poland. Source: own analysis as per Web of Science (2022).

Polish authors are pictured in Figure 13. The following writers are significant contributors to the broadening of perspectives in the field: Orlowski, A., Orlowski, C., Kaplanski Kourtut, Nijkamp, etc. They will be incorporated into the model for assessing scientific output in the context of smart cities under V4 conditions.

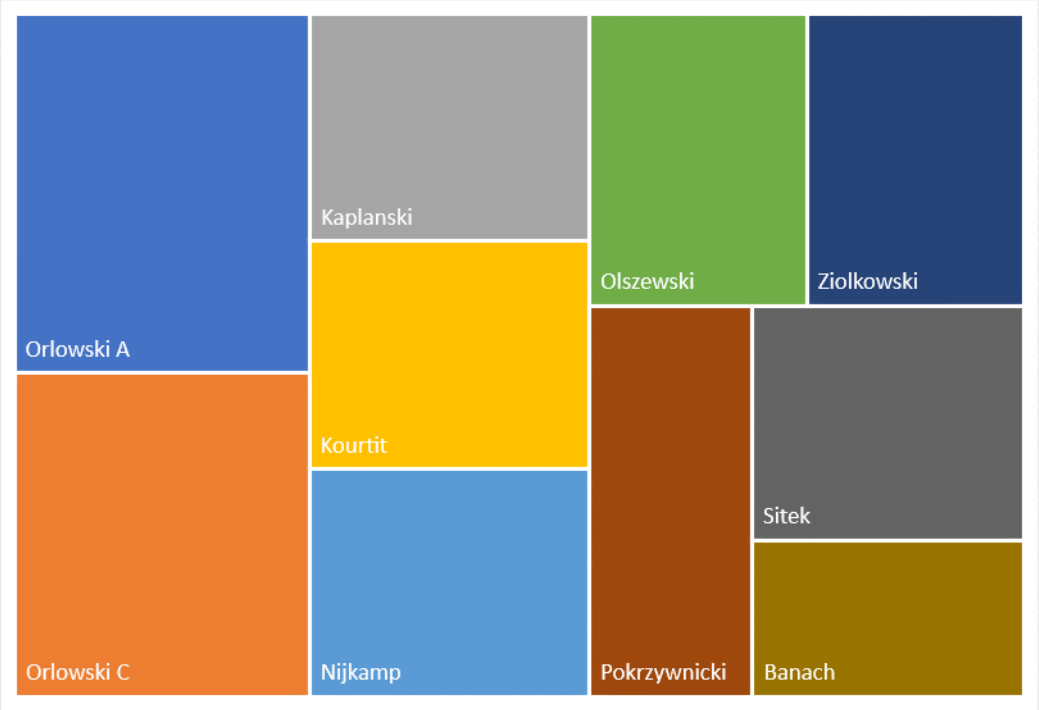

Figure 13. An overview of Polish authors publishing on the topic of Smart cities. Source: own analysis as per Web of Science (2022).

Hungary is only beginning to share its knowledge and research on smart cities with the scientific world. The most notable year was 2019, when 15 articles were published. The number of citations peaked in 2021, when articles written by Hungarian writers reached 145. Figure 14 depicts a summary of the quantity of citations and publications.

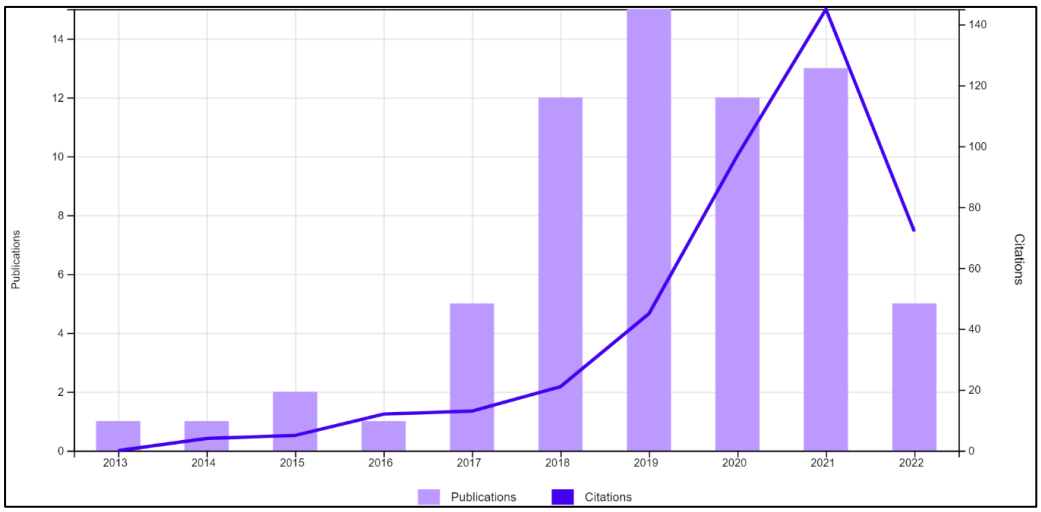

Figure 14. An Overview of publications and citations on the topic of Smart cities in Hungary. Source: own analysis as per Web of Science (2022).

The following notable Hungarian authors have written about smart cities: Simon, Naked, Master, Feher, Farkas, etc. (Figure 15). They will be incorporated into the model for assessing scientific output in the context of smart cities under V4 conditions.

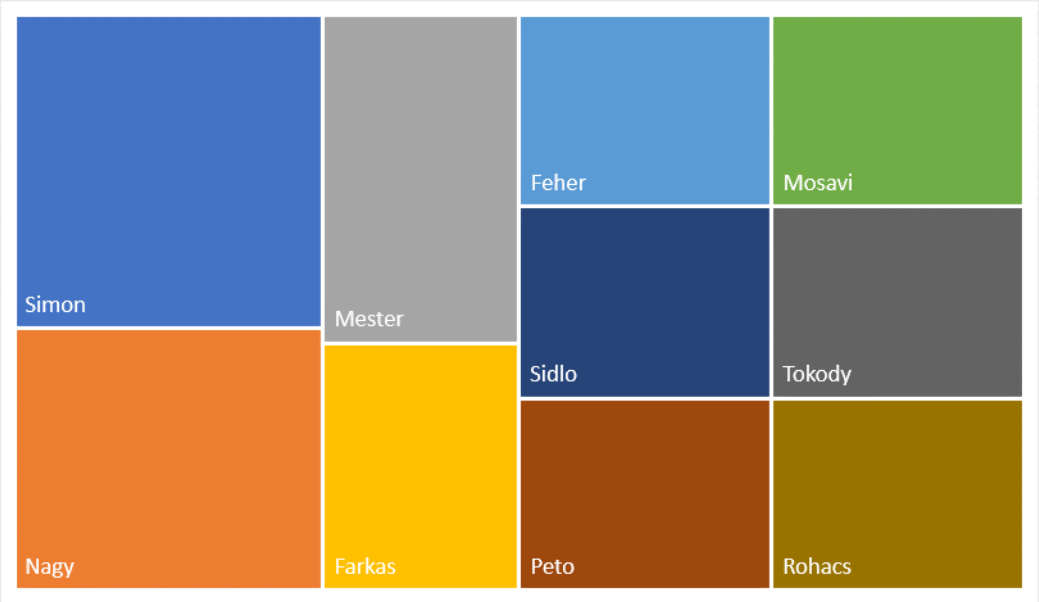

Figure 15. An overview of Hungarian authors publishing on the topic of Smart cities. Source: own analysis as per Web of Science (2022).

As may be seen, the problem of Smart cities is one that scientific researchers are now working to tackle. The scholars whose work was summarized in the preceding paragraph are employed by a number of top colleges in the Visegrad Four. The accompanying tree map (Figure 16), which includes the 15 institutions most actively involved in addressing the topic of smart cities, was created to provide readers with a clearer understanding. The institutions will be incorporated into the model for assessing scientific output in the context of smart cities under V4 conditions.

This section discusses another approach of the Slovak, Czech, Polish, and Hungarian authors on the topic of Smart cities and awareness surrounding it. Some authors, such as Silar et al. [103], concentrate solely on enhancing the quality of parking logistics in cities, while other authors approach the Smart city from the perspective of developing a smart application that would alert city residents to all events and provide them with the necessary information, based on which the quality of life in the city would be improved overall. As examples of such authors, see Moch and Wered [104]; Orlowski and Romanoska [105]; Kashef et al. [106]; and Borsekova and Graczyk-Kucharska [107]. Many people believe that a Smart city should be able to handle any traffic problems, parking issues, or transit issues. Some authors also examined this topic from the perspective of security, namely the development of a secure Smart city. These authors include Ristvej et al. [108]; Peto [109]; Peto [110]; Peto and Tokody [111]; and Lacinak and Ristvej [112]. In fact, these divisions of the smart city perspective are not the whole picture. Prochazkova and Prochazka [113] focus on critical infrastructure in their scientific article. Ejaz et al. [114] address the issue of noise pollution. Kalasova et al. [115] target the model of sustainable city development in their study, and Barufi and Kourtit [116] focus on agglomeration economies.

In any city, there are people of all ages. Young people will undoubtedly live closer to a Smart city than pensioners do. Because of this, it is important that one author, Szabo [117], developed a system that is also user-friendly for senior citizens. Urban ecology is another problem that scholars are interested in. Svitek et al. [118] have tackled this problem. All intelligent systems, applications, etc., require storage, which needs to be large enough to store data, fast enough to evaluate it, and be able to receive and send data efficeiently, and

be connected to the network properly. The network also needs to take backup sources into account so they can be used in the event of a network failure. Adams et al. [119] and Horak and Tykva [120] address this problem.

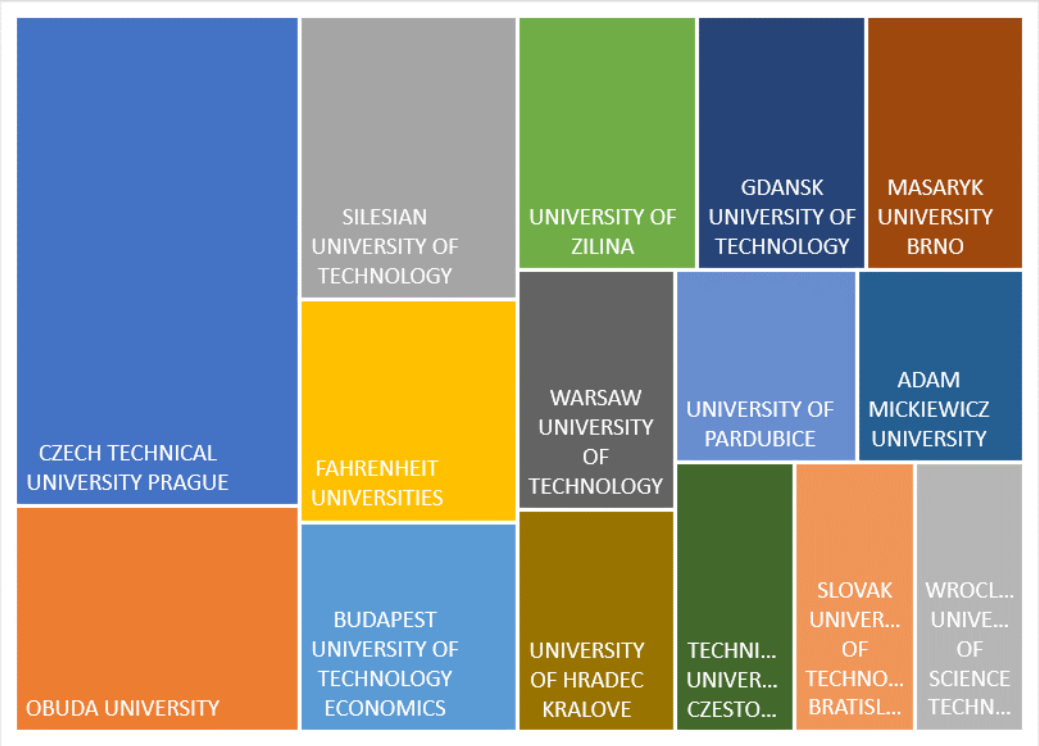

Figure 16. An overview of the V4 universities that publish the most on the topic of Smart cities. Source: own analysis as per Web of Science (2022).

4. Conclusions

The idea of Smart cities is expanding steadily around the world. This concept and its tools contribute to improving the quality of life for the residents. The V4 countries are also involved in the implementation and clarification of this concept in theory as well as practice. This involvement of states and their scientists and authorities changes the overall idea and awareness, and more and more states note that their standard of living, transportation quality, air quality, noise levels, dispatching, and economic, cultural, and social events have reached a level that meets the standards of the twenty-first century. The aim was to determine the level of involvement of V4 countries in solutions for Smart cities using Web of Science data.

The given issue was solved by running of VosViewer and graphical processing. For each country in Visegrad, the status of the authors, the number of papers and citations, and universities were detected and visually represented. The findings showed that the V4 countries have been lax in addressing the challenges of Smart cities. But their trend has been moving up the global rankings every year. The implication for researchers is the labeling of the institutions and authors that have contributed to long-term solutions to this issue from the analyzed region. The municipalities of V4 nations may use highlighted clusters of critical areas that are crucial to Smart cities and give their residents a better quality of life.

This research was also faced with limitations that are truncated as they result from the use of scientific articles only from the Web of Science database. Another limitation may be the fact that the article is mainly focused on V4 countries. It follows that future research would include more countries that would be compared to each other in a similar way as in this V4 country article. Additionally, in future researcj the Web of Science database would be supplemented with outputs from the Scopus database and ProQuest, and then

the given outputs could be compared with each other, and a conclusion would be obtained as to which scientific database is used most often by scientists to publish outputs covering Smart cities. The issue of Smart cities may be extended to the area of Knowledge cities. But prior to that, the next stage of the research is to test the dependence between the number of authors of a publication, its citations, and the impact factor of the publishing journal, followed by our own scientometric model of scientific output convering the issue of Smart cities so as to rank countries. In addition, the next stage would pioneer the digital twin modelling of Smart cities in the conditions of V4 countries.

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