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SMART city and economy: bibliographic coupling and co-occurrence

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Abstract. Rapid development of advanced technologies and their use bear crucial influence on Smart City development. Smart economy ranks among key Smart City components. The rising awareness of the importance of Economy in Smart cities becomes a widely discussed issue and gets reflected in professional literature. The aim of the paper is to map and analyse the state of usage of current topics and terms "SMART city" and "economy" and their bibliographic coupling and co-occurrence on Web of Science. The analysis focuses on published documents and their citation, use of journals for publishing of articles, authors that have the most articles, number of published documents in countries. The reoccurrence of the most often used key words in the articles will be analysed. Analysis was done in March 2019 via VOSviewer software. The highest number of articles is presented in Smart economy in smart cities, Journal of cleaner production and Cities. USA and India are the countries with highest number of articles. Smart city, Cities, Smart cities, Governance, Innovation, Big data, Economy and Urbanization are the most often used keywords.

Keywords: bibliographic coupling, co-occurrence, Economy, SMART city

1 Introduction

The introduction and literature review briefly describes the potential of the study in a broad context and highlights the importance of the discussed topic. The purpose of the work and its significance are defined in this chapter. The current state of the research is reviewed carefully and key publications are cited. Then principal conclusions are formulated reflecting the main goal of the paper.

In the globalized world, there is growing concern about economic growth and economy. Development of technologies and use of ICT brings a lot of benefits to society, economy, citizens, companies, cities and next stakeholders. A lot of people use advanced technologies in their daily lives. Technologies are not used only by citizens, companies, but also by governance and cities. The phenomenon of Smart Cities has been experiencing a rising interest in the academic sphere in recent years. The first article on Smart Cities that appeared in the Web of Science database was 'Smart cities - The Singapore case' by Mahizhnan [4]. With 81 citations it is nowadays one of the most cited article on selected topic.

Graham and Aurigi [2,3] appeared in 1997 the concept of a smart city. The possibility of using ICT tools for communicating with residents was one of the impulse. Next one was collecting data or using this data to manage the city. To state one universal definition of the concept of a smart city is difficult. The report entitled Smart Cities—Ranking of European Medium-Sized Cities [5] defined the idea of 'smart city' quite broadly. According to report "smart city is a city well performing in a forward-looking way in six characteristics [economy, people, governance, mobility, environment, and living], built on the smart combination of endowments and activities of self-decisive, independent and aware citizen". Caragliu et al. [6] defines smart city with the conditions "when investments in human and social capital and traditional (transport) and modern (ICT) communication infrastructure fuel sustainable economic growth and a high quality of life, with a wise management of natural resources, through participatory governance."

Hall et al. [31] in 2000 indicated that "a city that monitors and integrates conditions of all of its critical infrastructures, including roads, bridges, tunnels, rails, subways, airports, seaports, communications, water, power, even major buildings, can better optimize its resources, plan its preventive maintenance activities, and monitor security aspects while maximizing services to its citizen". Therefore, 'smart city' in this definition was associated with the use of ICT to support the delivery of public services.

"Unquestionably, cities are complex systems and the rapid urban growth that brings traffic congestion, pollution, and increasing social inequality may turn the city into a point of convergence of many risks (economic, demographic, social, and environmental)." [7]

"Smart cities provide major economic, social, and productivity benefits to all stakeholders. But without the right vision, plans, talent, and funding in place, smart city programmes will not reach their full potential." [1]

The issue of Smart Cities has been solved for several years. Many of the cities that have been considered successful in terms of Smart Cities will continue to have considerable place for improvement. In this topic are mostly solved technological issues, but economic view of point is not solved so often.

2 SMART city x economy

"Historically, cities are considered as the highest forms of economic and sociocultural achievements in human civilization, and the location of non-primary economic activities". [8]

"When the devices start becoming smarter, it inevitably leads to a smarter ecosystem of devices. The extension of such a development forms something that is called a smart city – A whole city that uses electronics to keep the area running at high or peak efficiency. A recent whitepaper from ABI Research concludes that smart cities will see an overall economic development of 5% annually, which translates to almost $20 trillion in a decade. This again validates that smart cities are a great investment that can impact the economy in a positive way." [9]

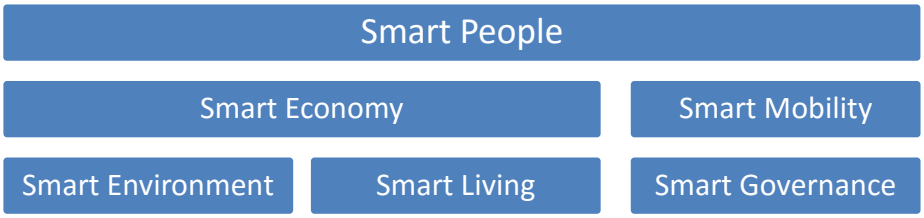
Deloitte presents three key differentiators of a smart city [10]:

- “Quality of life
- Economic competitiveness
- Sustainability

Economic competitiveness is presented as cities have long been important centers of trade and commerce, leveraging the proximity of so many diverse citizens to help drive an innovative economy. A smart city is a business-friendly city, ensuring that jobs and tax revenue form a healthy economic platform.”

Cities are as “´engines of economic growth´ and dominate local and national economies.” Smart City System building blocks by Kumar [11] are presented in fig. 1.

Fig. 1. Smart City System [11]



A city has many areas in which it can be managed to transform itself into a smart city. Six basic directions for action will enable it to direct its objectives along this route, according to the definition of smart cities given by Boyd Cohen [12], an urban development researcher, see fig. 2.

Fig. 2. The six action areas of smart cities [12]

The smart economy: “it is a city that wants to position itself as a capital of the new economy and innovation as well as a centre that draws people to it.” [12]

3 Methodology and goal

Steps of the research are as follows. Firstly, there is the introduction to the topic. The methodological background brings the aim and goal of the study, description of the study procedure and used sources. The literature review contains basic definitions and the starting points to selected issues. The next phase deals with results from bibliographic coupling and co-occurrence of selected keywords. The final phase focuses on summarization and discussion of findings gained from the research.

The aim of the paper is to map and analyse the state of usage of current topics and terms “SMART city” and “economy” and their bibliographic coupling and co-occurrence on Web of Science. Focus will be given on documents and their citation, use of journals for publishing of articles, authors that have the most articles and number of published documents in countries. In co-occurrence will be analysed the most often used keywords in the articles. The previous studies basically focus only on a certain perspective. Visual bibliometric analysis on connected topics smart cities and economy was not founded. This study employed scoping review techniques to dissect the status quo for SMART city and economy. Our search of scientific and research sources focused on scientific sources. The bibliometric mapping study method by Leung, Sun, & Bai [32] and scoping review technique by Arksey & O’Malley [33] were adopted in this review-based article.

The number of co-occurrences and total strength of the co-occurrence links with other keywords for each of the selected keywords were generated in VOSviewer. Co-occurrence is the term used to describe the proximity of keywords in the title, abstract, or keyword list in publication (Van Eck & Waltman, [34]) to find connections so that the research topic can be identified (Wang et al., [35]). The link indicates the strength of their occurrences. These methods were used also by Maskuriy et. al. [36].

Two terms were searched 15th of March 2019 in the Web of Science database. “SMART city” AND “economy” were put into query. There were 275 articles found in all publications. There were 147 articles in journals and book chapters found in total. Then there were 128 findings in Proceedings papers, 3 in editorial material and 2 in reviews. Only articles in journals and book chapters were included into the next evaluation.

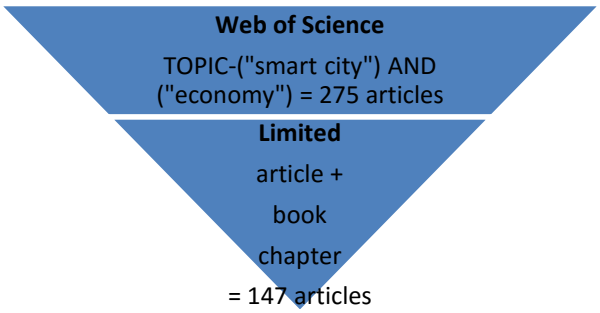


Fig. 3. Selection of documents in bibliometric analysis

In case of searching the term “economics” instead of the term “economy” only 22 articles were found. Due to this reason, the term “economy” was used in the query in the next evaluation. Full record and cited references were saved as Other Reference Software and uploaded to VOSviewer. The analysis that is presented in this paper was made via VOSviewer. Analysis is made between selected sources if it is not written in another way in the text.

The article is established on secondary sources. The secondary sources provide information about smart city and economy, information gained from professional literature and databases and from professional press, from web sites, discussion at professional seminars and conferences related to smart cities and economy. Then it was necessary to select, classify and update accessible relevant information from the high number of published materials that provide the basic background about the solved issue.

4 Results

Graphs and tables that represent the outputs from VOSviewer are shown in this chapter. Into evaluation were taken such criteria that are interesting in publishing of the articles. The highest number of citations on document, the most often used journal for publishing this topic, authors that published the highest number of the articles, in which country is the most often solved this issue. The last one solved issue are the most often set keywords connected with the topics.

4.1 Bibliographic coupling

Documents x number of citations

. The minimum number of citations of a document was selected 10. Out of 147 documents, 19 documents meet the threshold. For each of the 19 documents, the total strength of the bibliographic coupling links with other documents will be calculated.

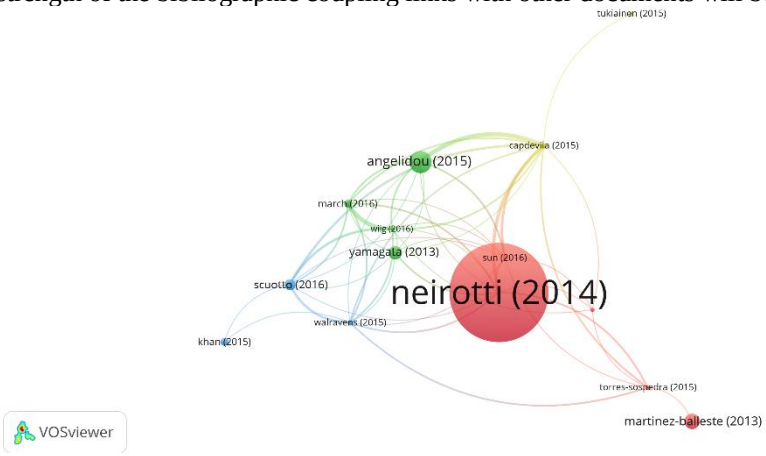


Fig. 4. Bibliographic coupling – documents

The documents with the greatest total link strength will be selected. Some of the 19 items in the network are not connected with each other. The largest set of connected items consists of 14 items. Results are presented in fig. 4. Four clusters were founded. The biggest is composed of 5 authors. Ferrara [13], Martinez-Balleste [14], Neirotti [15], Sun [16] and Torres-Sospedra [17]. The second cluster composed of 4 authors. Angelidou [18], March [19], Wiig [20] and Yamagata [21]. The third composed of Khan [22], Scuotto [23] and Walravens [24]. The last one consisted of Capdevila [25] and Tukiainen [26]. Alone are publicatons of Hens [27], Shuai [28], Das [29], Hernandez-Munoz [30] and Mahizhnan [4]. Results of number of citations are presented in tab. 1. Number of citations are taken directly from Web of Science.

Table 1. Documents x number of citations x clusters

Authors	Citations	Authors	Citations
Ferrara	16	Scuotto	45
Martinez-Balleste	72	Walravens	23
Neirotti	396	Capdevila	22
Sun	20	Tukianinen	16
Torres-Sospedra	19	Hens	15
Angelidou	102	Shuai	22
March	35	Das	10
Wiig	10	Hernandez-Munoz	101
Yamagata	54	Mahizhnan	81
Khan	32		

Sources – journals x documents

. Minimum number of documents of a journal is 4. Of the 98 journals only 4 meet the thresholds. Due the small number of journals were criteria reduced on 3. Only 7 from 98 sources meet the thresholds. For each of the 7 journals (see tab. 2 and fig. 5), the total strength of the bibliographic coupling links with other sources will be calculated. The journals with the greatest total link strength will be selected.

Table 2. Bibliographic coupling – journals (sources)

Source	Documents	Citations	Total link strength
Journal of cleaner production	7	19	159
Cities	7	562	154
Sustainability	5	6	88
Smart economy in smart cities	20	10	74
Telematics and informatics	3	28	58
Sustainable smart cities in India: challenges and future perspectives	3	0	40
Sustainable smart cities: creating spaces for technological, social and business development	3	0	31

Two clusters were found in journals (sources). By red is marked one and by green the second one.

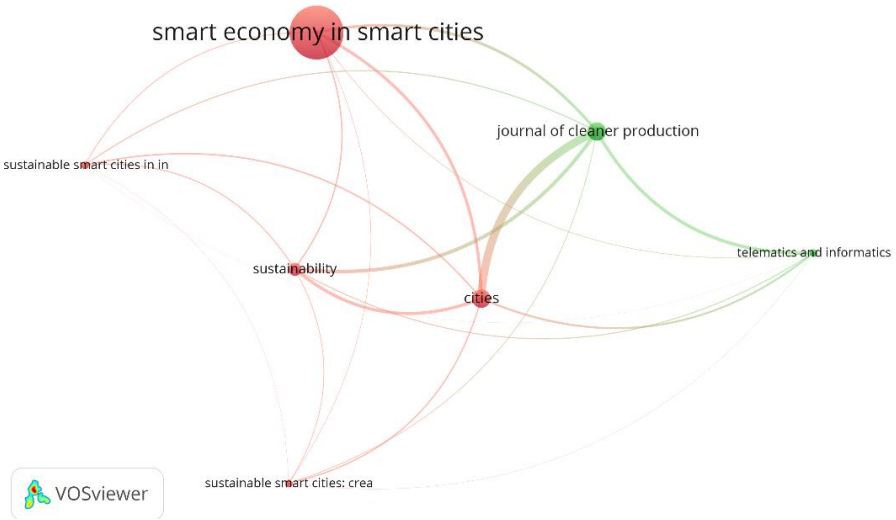


Fig. 5. Bibliographic coupling – sources

Authors x documents

The minimum number of documents of an author was set at four. Only 3 authors meet the thresholds of the 403 authors. Criteria were reduced to 3 documents of an author and 7 authors meet the thresholds. In case of further reduction to 2 documents of an author, 37 meet the thresholds. The highest number of publications have Mboup, G. with 6 documents. 4 documents presented Kumar, T.M. Vinod and Mwaniki, D. 3 publications published Spruijt, W., Rodgers, T., Govada, S.S. and Alizadeh, T.

Country x documents

. Minimum number of documents of a country was set at 5. 9 countries meet the thresholds of the 53 countries. The total strength of the bibliographic coupling links with other countries will be calculated for each of the 9 countries (see tab. 3 and fig. 6).

Table 3. Bibliographic coupling - country

Country	Documents	Citations	Total link strength
Italy	16	452	950
Spain	16	231	815
USA	18	46	774
Peoples r. China	13	22	682
England	11	69	605
India	18	12	469
France	8	57	431
Australia	8	20	337
Russia	7	51	281

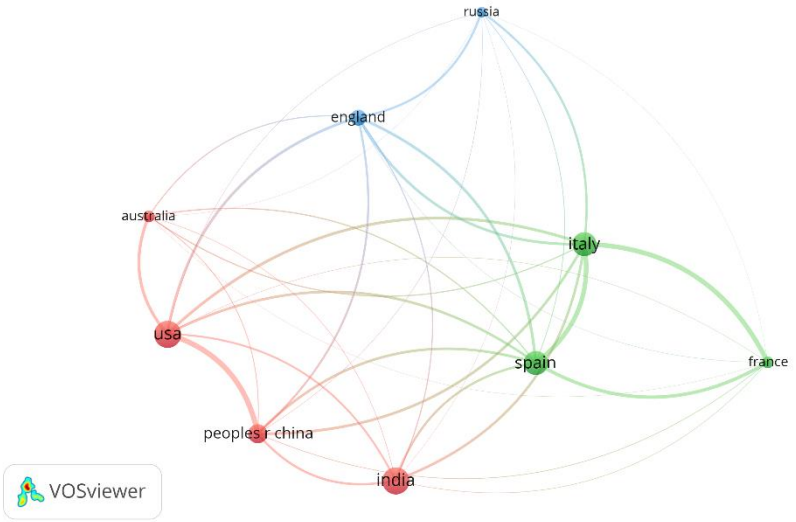


Fig. 6. Bibliographic coupling - country

The highest number of articles were written in USA and in India followed by Italy, Spain, Peoples Republic of China and England. The highest number of citations was done in Italy, Spain, England, France, Russian Federation and in USA.

Three clusters of countries were found in the cluster analysis. The first cluster composed of Australia, India, Peoples R. China and USA. The second cluster composed of France, Italy and Spain. The third one from England and Russia.

4.2 Co-occurrence

All keywords

Minimum number of occurrences of a keyword was set at 6. 19 keywords meet the threshold of the 706 keyword (see tab. 4 and fig. 7). For each of the 19 keywords, the total strength of the co-occurrence links with other keywords will be calculated. The keywords with the greatest total link strength will be selected.

Table 4. Co-occurrence – all keywords

Keyword	Occurrences	Total link strength
Smart city	77	132
Cities	27	54
City	19	44
Governance	12	30
Innovation	13	30
Smart cities	21	30
Economy	9	29
Technology	8	25

Big data	11	21
Urbanization	9	21
Growth	8	19
Sharing economy	8	19
Future	6	18
Model	6	18
Politics	6	18
Sustainability	8	18
Urban governance	6	18
Internet of things	6	14
Open innovation	6	14

Internet, challenges, management, infrastructure, network, trends, urban planning, systems and sustainable development have 5 occurrences. Due better clarity will be in graph presented keywords with 6 occurrences and more.

There were identified 4 clusters. The first one composed of 7 items: cities, growth, Internet of things, model, open innovation, smart city and sustainability. Second composed of 6 items: city, economy, smart cities, technology, urban governance and urbanization. The third cluster composed of big data, future, innovation and politics. Together are also often used terms 'governance' and 'sharing economy'.

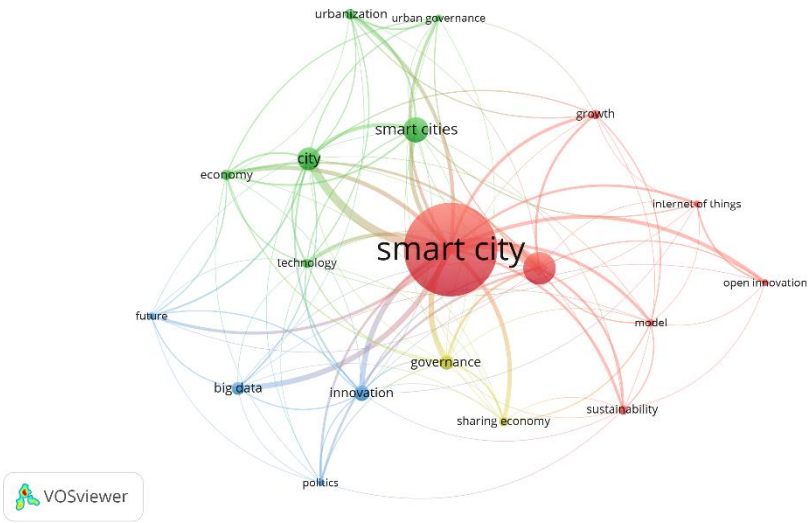


Fig. 7. Co-occurrence – all keywords

4.3 Limitations of the study

Science, technology, and innovations are engines to drive growth and sustainable development of SMART cities all over the world.

Due to the limited number of pages and depth of the research the limitations might be found in the following areas:

- Minimum number of citations of a document was set at10. In case that number of citation of the document will be smaller, more documents will meet the threshold. On the contrary, results will be not so well arranged.
- Number of documents in the journal was reduced due to the small number of journals (sources) with many relevant articles. The criteria were reduced to 3 papers per journal. 7 journals out of 98 sources meet the thresholds.
- Minimum number of documents of an author was set at 4. Only 3 authors out of 403 authors meet the thresholds. When the minimum number of documents by one author is reduced to 3 documents, 7 authors meet the thresholds. In case of 2 documents per author, the number of occurrences will increase.
- Minimum number of documents of a country was set at 5. Only 9 countries out of the 53 countries meet the thresholds. In case of a smaller number of documents, the number of countries meeting the thresholds will increase.
- Minimum number of occurrences of a keyword was set at 6. 19 keywords meet the threshold out of the 706 keywords. In case of smaller occurrence of a keyword, there will be higher amount of keywords.

5 Conclusion

Bibliographic coupling and co-occurrence measure a similarity that uses citation analysis to establish a similarity relationship between documents, authors, countries etc. A wide variety of fields may be applied in, since it helps researchers to find related research conducted in the past and to find the gap, nitch or necessities in the analysed field of study.

Topic Smart city and economy is getting its importance more and more. First article was into Web of Science included in 1999 where Mahizhnan wrote [4] that “the final goal is not just economic growth but an enhancement of the quality of life for all people, making Singapore not just a smart city but a quality city-state.” The next articles were published in 2011, for ex. [30] that was with 128 citations the most cited from the publication year. The gap was in 2012 and from 2013 till 2017 numbers of articles in journals or book chapters were still rising on 52. It fall on 43 in 2018.

Neirotti, Paolo; De Marco, Alberto; Cagliano, Anna Corinna; et al. [15] with 378 citations with publication Current trends in Smart City initiatives: Some stylised facts in journal Cities recorded the highest number of citations from all authors. Hernandez Munoz, et. al. were cited 94 times [30], Angelidou [18] was cited 85 times and Mahizhnan [4] 79 times in database Web of Science. Sources as Cities with 562 citations, book Future Internet: Future Internet Assembly 2011: Achievements and Technological Promises with 94 citations, IEEE communications magazine with 60 citations, Applied Energy with 53 and Business Process Management Journal with 43 citations are the most often cited. Topic is the most often solved in Italy, Spain, USA and India. Smart city, cities, city, governance, innovation, smart cities, economy, technology and big data are the most often published keywords connected with topic Smart

city and economy. According to above mentioned words and done analysis is Smart city also often connected with keywords technology, urbanization, growth, sharing economy, future, model, politics, sustainability, urban governance, internet of things and open innovation. The creation of smart cities is a motivator for growth, new jobs and is a productive investment in future, leading to a sustainable and environmentally friendly economy. Well-arranged pictures presented in this paper demonstrate the research achievements in the domain of the smart city and economy, which could help researchers, practitioners and mayors and politics to identify the underlying impacts from authors, journals, countries, institutions, references, and research topics.

Future research will be focused on the most frequent occurrence of keywords used in the connection of the analysed issue and their combination with more detailed description so that a wider notion on the topic could be provided.

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