

The role of digital transformation in the development of the smart city: a bibliometric analysis

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Abstract— Studies on the role of technology in improving the urban landscape and improvements in citizen experiences have been increasing recently due to the growing movement to transform conventional urban landscapes into cities capable of use information and communication technologies to improve the quality of urban services and make the city more adaptive and efficient.

This study aims to analyze existing research on the role of digital transformation in the development of smart cities. Scopus' data-driven analysis system and VOSviewer software were used to generate 901 publication documents for graphical and visual analysis of research trends.

This study hopes to help fill the gap of bibliometric analysis concerning the subject.

Keywords— *Digital transformation, smart city, bibliometrics, Scopus, Vos Viewer*

1. Introduction:

The notion of digital transformation has appeared in the discourse of companies since the 2000s. While digitalisation generally describes the simple conversion of analogue information into digital information, the terms Digital transformation and digitalisation are used interchangeably and refer to a broad concept affecting political issues, commercial and social.

Collin et al. (2015) [1]; Gimpel and Röglinger (2015) [2]; Kane et al. (2015) [3]. This digital transformation leads to profound organizational changes by making collaborative platforms and tools a cornerstone of the new work environment of Dudézert employees (2018) [4].

Digital transformation then corresponds to the changes that digital technology causes or influences in all aspects of human life Stolterman and Fors (2004) [5]. It can be defined as the use of technology to radically improve the performance or reach of companies and organizations Westerman et al. (2011) [6]. This digital transformation cannot be tackled without the digital technologies associated with it, notably the Cloud, Big Data, Big Data Analytic and the Internet of Things

Towards the end of the 2000s, companies specializing in the IT sector, such as Cisco, IBM, Siemens or Toshiba, finding in urban policies a potential for growth, decided to play an innovative role in the design and delivery of urban services.

We are then witnessing the emergence of the smart city, the model for optimizing urban functioning through data. The smart city has therefore been deployed in cities thanks to the services offered by companies in the digital economy. Which services have transformed urban practices and made cities more adaptive and efficient.

Our research question is: How has scientific production evolved on the subject of the role of digital transformation in the development of smart cities over the last twenty years? to answer this question, we will proceed with a bibliometric analysis.

In this research paper, we will successively present our bibliometric research methodology, the results obtained and their discussion.

2. Methodology:

Bibliometry is a quantitative analysis based on statistics and using existing literature to evaluate the development of a theme (Gao, Huang, & Wang, 2018) [7]. It is considered to be one of the most common methods accepted by theoreticians, notably because it is a determining tool in the evolution of scientific productivity, and measures the quality of research in a given field (Rodríguez-Bolivar, Alcaide-Munoz, & Cobo, 2018) [8].

Technically, bibliometry is based on two types of analysis. The first, the statistical analysis of the study's bases, aims to determine the productivity of authors, journals and countries in relation to the theme of the study. The second, that of the analysis of co-occurrences, allows to generate bibliometric networks for the bibliographic coupling and the co-occurrence of key terms of the theme of the study. The combination of these two analyses makes it possible to understand how documents, authors and keywords are linked to each other and to identify areas and trends for future research (Terán-Yépez, Marín-Carrillo, Casado Belmonte, & Capobianco-Uriarte, 2019) [9].

The bibliometric analysis tool used is VOSviewer. It is, in fact, a software widely used for bibliometrics, particularly because it allows to graphically represent and visualize large maps that are easy to interpret (Van Eck & Waltman, 2010) [10].

To operationalize our research, we filled in the VOSviewer, as the basis of the analysis, the keywords: Digital transformation and public organizations and we fixed the minimum number of co-occurrence of a word-key to 1. To deepen the various topics of existing studies, we have extended the use of VOSviewer to analyze terms in the title and summary fields of existing studies.

We then proceeded to a set of document-limiting exclusions before exporting the data for meta-analysis. These limitations included the year of publication (2000 to 2023) and the stage of publication (final state).

After searching and reviewing the document results, the data is exported to the Excel CSV file, including citation information, summary and keywords. Thus, the extracted Excel CSV file was processed using VOSviewer to generate a study database consisting of 901 articles. Using VOSviewer allows researchers to visually understand meta-analysis by presenting the label view, density view, cluster density view, and dispersion view.

3. Result and discussion:

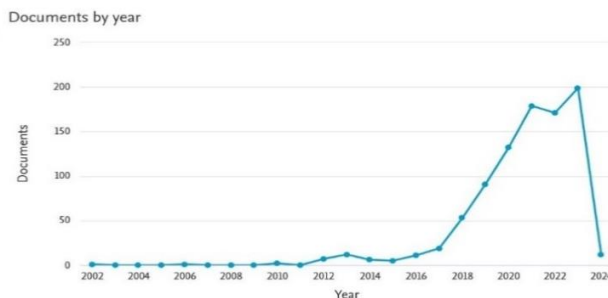
3.1. Evolution of scientific production on the role of digital transformation in the development of smart cities:

We then analyzed the statistical characteristics of this study base according to the criteria year of publication, type of publication, country of publication, authors and scientific fields.

The distribution between years of publication:

Over the past twenty years, the number of published research on the role of digital transformation in the development of smart cities has been less than 100. Significant growth in publications can be seen since then, with 132 publications in 2020, 179 publications in 2021, 171 publications in 2022 and 199 publications in 2023. This indicates, in our view, on the one hand, the recent nature of this theme, and on the other hand, the growing interest of academics to focus their research on the subject during the last five years, in particular following the pandemic crisis of Covid19.

Fig. 1: Documents by year

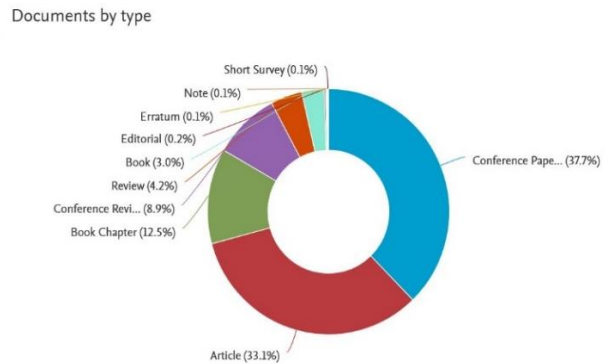


The breakdown by type of publication:

Of the total publications relating to the role of digital transformation in the development of smart cities identified over

the period, 37.7% corresponds to conference papers, 33.1% corresponds to scientific articles and 12,5% in book chapters or more than 80% of the total.

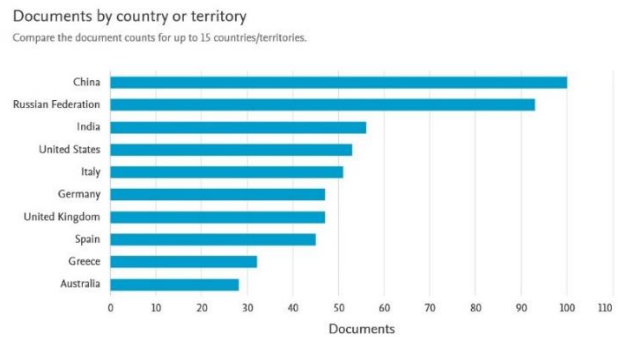
Fig.2: Documents by type



The breakdown by country:

All research published over the period was conducted in China with 100 searches, followed by Russia with 93 searches, India with 56 searches, the United States with 53 searches, Italy with 51 searches, Germany and the United Kingdom with 47 searches each. This confirms, in our view, the observation of the rise of the BRICS countries (China, Russia, India and Brazil) in the field of scientific production in general, that concerning the theme of digital transformation and the smart city in particular, compared to those of the G20 (EU, Germany, United Kingdom, Italy and Spain...)

Fig.3: Documents by country

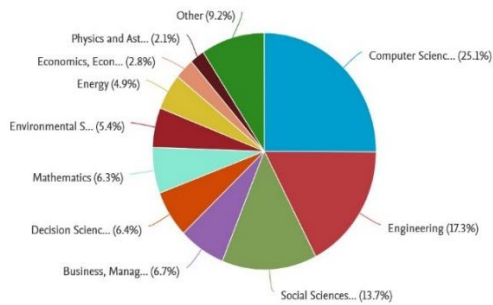


The breakdown by scientific area:

25.1% of publications are in computer science, 19.2 in social sciences, 17.3% in engineering, 13.7% in social sciences, 6.7% in management, 6.4 in decision science, 6.3 in mathematics, 5.4 in environmental sciences and 4.9 in energy. That is a total of more than 50% of publications in the computer and engineering fields and more than 30% of publications from the sciences of organizations (social sciences, management, and decision-making).

Fig. 4: Documents by area

Documents by subject area



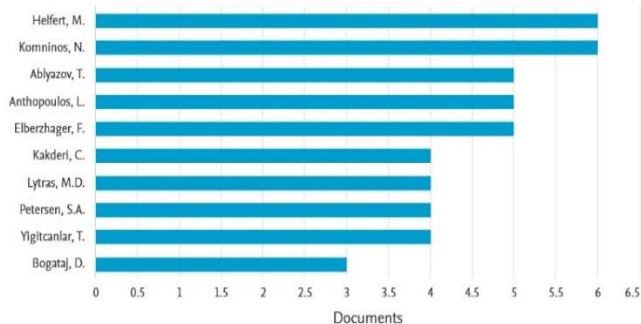
The breakdown by authors:

The authors with the largest number of articles are respectively Helfert M and Komninos N with 6 publications each, Ablazov T, Anthopoulos L and Elberzhager F with 5 publications each, Kakderi C, Lytras M.D, Peterson S.A and Yigitcanlar T with 4 publications each and Bogataj D with 3 publications. It is essential to mention that the rest of the authors have a number of publications less than or equal to 3 publications, each, on the subject.

Fig. 5: Documents by author

Documents by author

Compare the document counts for up to 15 authors.



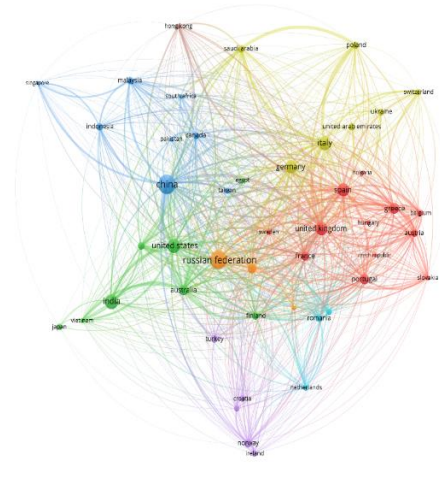
3.2. Bibliographic coupling analysis

Bibliographic coupling by country

We speak of bibliographic coupling when there is a common reference in two documents. Bibliographic linking helps measure similarity between research sources, which can be used to explore similarities across different searches. In the case of countries, bibliometric coupling occurs when two countries cite the third country in their publications. This highlights how other countries use similar literature in their publications and focus on a similar topic. The results of the country bibliographic linkage are presented in the form of circles which represent countries/regions and colors which indicate clusters. It is possible to notice that countries of the same color tend to mainly concentrate or face the same problems. On graph no. 6, we can see 8 clusters indicating the countries focusing on or concentrating on solving the same research problems linked to the theme of the role of digital transformation in the

development of smart cities. Thus, Russia, China, the United Kingdom, the United States, Germany and Italy are countries which focus on the same research themes on the subject of the role of digital transformation on the development of smart city.

Fig. 6: bibliographic coupling by country

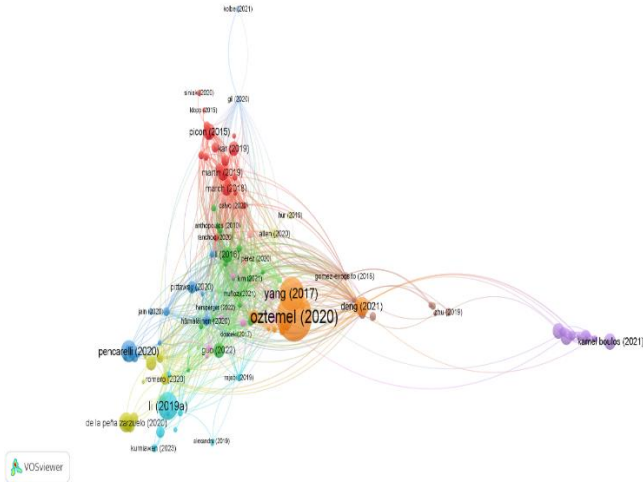


Bibliographic coupling by documents:

The bibliographic coupling map by document illustrates the presence of connections between pairs of elements. Bibliographic coupling links and co-occurrence links are highlighted in this study. These links provide information about the nature of the relationship between the articles. Indeed, each link is characterized by a specific intensity level, which is represented by a numerical value. Thus, a high value indicates a strong interdependence between the elements and the number of publications in which two terms appear simultaneously represents the strength of the links. That said, the links and articles form a combined bibliographic network.

The result of the bibliometric mapping illustrated in figure no. indicates the collaboration and connection in the research field in relation to our theme as well as the contribution of each author to his or her field of research. Thirteen groups or clusters can be identified with different colors. On the other hand, the distance between two elements in a bibliometric network gives an indication of the strength of their connection. Thus, the purple cluster houses themes or areas of research that are not close to the other clusters.

Fig. 7: Bibliographic coupling network by document



In Table I, we can clearly see the authors who obtained the highest Total link strength score using the bibliographic linkage network.

TABLE I: Total link strength

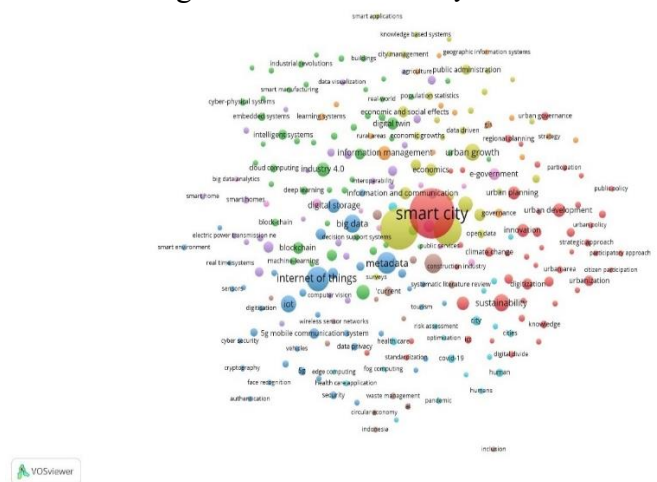
Document	Citations	Total link strength
mora (2023)	23	131
pereira (2022)	12	121
ahvenniemi (2021)	20	106
kim (2021)	17	99
march (2018)	84	93
orejon-sanchez (2022)	23	90
muñoz (2021)	17	72
li (2016)	105	71
wu (2023)	35	64
komininos (2021)	20	63
shayan (2020)	17	55
gil (2020)	28	54
hamäläinen (2020)	46	53
liu (2022)	10	52
león (2020)	48	52
martin (2019)	102	51
deng (2021)	168	50
preston (2020)	27	50
allen (2020)	49	48

3.3. Keyword co-occurrence analysis:

The analysis of the co-occurrence of keywords in publications provides information on the main research themes relating to the subject of the role of digital transformation in the development of the smart city as well as on the trends in this research.

On the VOSviewer we selected all the keywords as the basis of the analysis, and we set the minimum number of co-occurrence of a keyword to 5. In order to deepen the different topics of existing studies, we extended the use of the VOSviewer to analyze terms also in the title and abstract fields of existing studies. Of the 5172 keywords, 260 reach the threshold.

Fig. 8: Co-occurrence of keywords



In Figure 8, the size of the nodes indicates the number of occurrences. Indeed, the larger the node, the more the keyword appears and the more occurrences of the term.

As we can see in Figure No. 8, the most recurring keywords are divided into 9 clusters, the summary is presented in Table II below.

TABLE II: Summary of item co-occurrences

Cluster	Items	Color	Links	Total link strenght	Occurrences
1	Smart city	Red	257	2224	430
4	Digital transformation	Olive green	251	1526	302
3	Internet of thing	Bleu	206	806	104
8	Sustainable development	Brown	162	471	67
7	Information management	Orange	115	245	36
2	Industry 4.0	Green	96	213	35
9	E government	Pink	48	102	24
5	Automation	Purple	84	168	21
6	City	Light Bleu	71	123	16

We can see in Figure 8, as well as in table II, that cluster n°1 in red is the largest and brings together the central term of the research, namely “Smart city”. Cluster No. 4, olive green, comes in second position in terms of importance and it relates to the term associated with the central theme, namely “digital transformation”. Cluster No. 3, blue in color, is third in importance. It indicates the theme “Internet of things”, a theme very associated in the literature with the combination “role of TD in the development of the Smart city”. Clusters n°3 (blue) and n°8 (brown), larger in size than the rest of the clusters, bring together central terms in relation to the theme, in particular “internet of things” and “sustainable development”. This also reflects the high occurrence of these keywords in the co-occurrence analysis. While clusters n°7(orange), n°2(green), n°5(purple), n°6(light blue) and n°9(pink), are smaller in size and indicate terms such as “information management”, “industry 4.0”, “Automation”, “City” and “e-government”. This indicates their rank of importance in relation to the research

theme. In addition, we can notice that cluster n°6 (red), n°4 (green), n°3 (blue) and n°8 (brown), represent research areas which are close to each other. While clusters n°7 (orange), n°2 (green), n°5 (purple), n°6 (light blue) and n°9 (pink) are more dispersed from the two central terms of the theme of research. Indeed, the distance between terms reflects the similarity between them. The greater the distance, the greater the difference. (Waltman & Van Eck, 2019). Other nodes can also be observed on graph No. 6, of an even smaller size and which are further away from the main items of the research theme, in particular "urban governance", "citizen participation", "smart environment". », "smart home", "city management", "citizen engagement" and "intelligent building". Ils indiquent des items encore périphériques à la thématique centrale de la recherche et par conséquent, représentent à notre regard des pistes potentielles de développement de la recherche sur cette thématique.

4. Conclusion:

The purpose of this bibliometric study was to explore existing publications in the Scopus database on the subject of the role of digital transformation in the development of smart cities, in order to have an overview of the main aspects that characterize this area of research.

Thus, our bibliometric analysis first reveals that research related to this subject has grown over the last five years (2019-2023), which reflects the growing interest of the academic community in developing research on this theme. . On the other hand, the strongest scientific production in this field comes from the BRICS countries (China, Russia, India and Brazil) and the G20 (EU, Germany, United Kingdom, Italy and Spain, etc.). The analysis of bibliometric coupling tells us, on the one hand, that Russia, China, the United Kingdom, the United States, Germany and Italy are countries which are looking at the same research issues relating to this subject. The analysis of the recurrence of terms shows that the main themes of existing research in relation to "digital transformation" and "smart city" are "internet of things" and "sustainable development". While themes such as "urban governance", "citizen participation", "smart environment", "smart home", "city management", "citizen

engagement" and "intelligent building" reveal a lack of research and therefore the potential development of research in this area.

Naturally, our bibliometric study has certain limitations. The first is that we carried out our research solely on the basis of Scopus data. The second is that the exploitation of the possibilities offered by the VOSviewer software was only partial. The study would gain in robustness if we go beyond these limits. Finally, we hope that our study has contributed to filling the gap in bibliometric analysis concerning the subject as well as to indicating new avenues of research to future researchers.

5. Bibliography :

- [1] S. Collin, N. Guichon, and J.G Ntebutse, Une approche sociocritique des usages numériques en éducation. STICEF, (22), 89-117. (2015).
- [2] H. Gimpel, M. Röglinger, Digital transformation: changes and chances? Insights based on an empirical study. Fraunhofer Institute for Applied Information Technology FIT, Bayreuth. (2015).
- [3] V.R. Kane, C.A. Cansler, N.A. Povak, J.T. Kane, R.J. McGaughey, J.A. Lutz, and M.P. North, Mixed severity fire effects within the Rim fire: Relative importance of local climate, fire weather, topography, and forest structure. Forest Ecology and Management, 358, 62-79. (2015).
- [4] A. Dudézert, La transformation digitale des entreprises. Paris, France : La Découverte. (2018).
- [5] E. Stolterman, and A.C. Fors, Information technology and the good life. Information systems research: relevant theory and informed practice, 687-692. (2004).
- [6] G. Westerman, C. Calmédjane, D. Bonnet, P. Ferraris and A. McAfee, "Digital Transformation: A Roadmap for Billion- Dollar Organizations", MIT Center for Digital Business and Capgemini Consulting, 2011.
- [7] H. Gao, F. Huang, and Z.P. Wang, Research Trends of Macrophage Polarization. Chinese Medical Journal, 131(24), 2968-2975. (2018).
- [8] M.P. Rodríguez-Bolívar, L. Alcaide-Munoz, and M.J. Cobo, Analyzing the scientific evolution and impact of e-Participation research in JCR journals using science mapping. International Journal of Information Management, 111-119. (2018).
- [9] E. Terán-Yépez, G.M. Marín-Carrillo, M. d. Casado Belmonte, M. d. and M. d. Capobianco-Uriarte, Sustainable entrepreneurship: Review of its evolution and new trends. Journal of Cleaner Production, 252. (2019).
- [10] N. Van Eck and L. Waltman, Software survey: VOSviewer, a computer program for bibliometric mapping. Scientometrics, 523-538. (2010).