

Research Progress and Trend Analysis of Digital Governance Based on Bibliometrics

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Abstract: In the past decades, digital governance has developed into an important research field, which deserves a systematic review and evaluation of its research status, topic evolution, and research prospects. Based on the Bibliometrics package, Vosviewer, and Citespace software, this study conducts bibliometric analysis in the field of digital governance research. The literature sample for this study is obtained from the Web of Science database, containing 2258 articles. First of all, through the analysis of the number of papers published, determine the publication trend of digital governance research. Secondly, through the citation analysis between authors and literature, the highly cited authors and important literature in the field of digital governance are discussed. Finally, through the knowledge structure analysis of the digital governance research field, including author, journal co-citation analysis, topic evolution analysis, and other methods, the topic evolution and future research direction of digital governance research are discussed.

1 INTRODUCTION

Digital governance refers to the behavior process of related affairs involving enterprises, social organizations, individuals, and other multiple subjects under the government's leadership, aiming to improve the level of digital governance by enabling the governance system through digital technology. Digital governance is a multi-level, complex, and dynamic research topic, involving communication, public management, law, network security, and other disciplines. And there is a lack of systematic research review on digital governance. By means of bibliometrics, this paper deeply analyzes the research topic of digital governance and its dynamic changes deeply analyze the existing research content of digital governance, points out the shortcomings of existing research on digital governance and puts forward research prospects based on this.

2 RESEARCH METHODOLOGY

2.1 Bibliometric Method

Bibliometrics is a method based on mathematics, statistics, and information science to study the development trend and subject field of a discipline through bibliometrics, knowledge graph, data visualization, and other relevant technical means. The commonly used tools of bibliometrics mainly include Vosviewer, Citespace, and the bibliometric toolkit in R language. This paper uses these three tools to conduct an in-depth analysis of the research status of digital governance.

2.2 Bibliometrics Toolkit in R Language

Bibliometrics is an R package based on literature network analysis. Compared with other R packages used for bibliometrics, Bibliometrics has more powerful functions and a more simple and direct presentation. The categories of functions of Bibliometrics include data import, descriptive statistics, co-occurrence matrix presentation, knowledge graph rendering, etc.

This paper attempts to use the toolkit to conduct citation analysis and theme evolution analysis of relevant literature on digital governance.

2.3 Vosviewer

Vosviewer is a Java-based free software oriented to literature data, suitable for the analysis of modular non-project networks, focusing on the visualization of scientific knowledge. The core idea of the software is "co-occurrence clustering," the idea that if two events occur at the same time, then there is a degree of correlation between them. There are many kinds of relationships that vary in strength and relationship to each other. Different types of clusters can be found by clustering the measurement indicators of relationship strength and direction. This paper will use this software to complete the co-citation analysis and literature coupling analysis of the digital governance literature.

3 CITESPACE

Citespace is an information visualization tool developed by Professor Chaomei Chen from Drexel University in the United States, which is specially used for academic literature analysis. It is suitable for multivariate, time-sharing, and dynamic complex network analysis, and can detect hot topics and their evolution in a certain discipline or field. At present, it has been widely used to detect and analyze the changing trend of the research frontier, the relationship between the research frontier and the knowledge base, and between different research frontiers. This paper tries to use Citespace software to conduct a co-citation analysis of digital governance research literature.

4 DATA COLLECTION

In order to conduct a bibliometric analysis of the field of digital governance, we first collected data from the Web of Science, including the Citation Index of Natural Science and Social Science, SCI and SSCI), and choose 1999-2022 as the literature research time of digital governance. The main reason for choosing to start the study in 1999 is that the relevant search terms are locked in "digital governance". The first title result is "Winds of Change: Digital technology, transaction information, and Intellectual Property management" (Tang, 1998). This paper focuses on the impact of digital governance on global and digital market

formation. After discussion, this paper is considered the beginning of research related to digital governance. The research period 1999-2022 is chosen to help find all articles on digital governance research by keyword. Then, based on the researchers' understanding of the field of digital governance, "digital governance", "e-government", "data governance", "algorithmic governance" and "platform governance" are selected as the final keywords of digital governance research. Then, the relevant keywords of the selected digital governance are extracted and analyzed. Finally, 2258 articles were selected for bibliometric analysis.

Then the collected data text is analyzed bibliometrically. Firstly, the built-in function of Web of Science is used to analyze the number of published articles included. Then, the Bibliometrics toolkit is used to analyze the number of published articles, authors, and citations, followed by word frequency analysis and topic evolution analysis. In addition, Vosviewer and Citespace are used for co-citation analysis. Finally, the research prospect is prospected according to the analysis results.

5 RESULT

5.1 Annual Publication Trend

As shown in Figure 1, scholars begin to publish publications on digital governance in 2003 according to the time distribution of publication years. The number of publications on digital governance fluctuates in the single digits from 2003 to 2011 and increases significantly each year from 2011 to 2021. In particular, in the past two years, the annual increase in articles reached more than 50. The increase in the number of papers indicates that digital governance has attracted more and more attention from the academic community, and a large number of research results have been published exploring the technological construction, application scenarios, policies, and regulations of digital governance, etc. This shows that the research field of digital governance is still in the stage of rapid development, the research results are constantly emerging, and the research prospect is relatively broad.

5.2 Source of Publication

Using the R language Bibliometrics toolkit for "the most relevant articles" function, to explore digital governance-related articles of use, The results are shown in Table 1. Based on the distribution of articles across journals, the most popular digital governance

study is Government Information Quarterly, with 36 articles.

Government Information Quarterly is an international journal exploring the intersection of policy, information technology, government, and the public. This is followed by sustainable development, with 32 and 20 papers published, respectively. The main themes of Sustainability include definition and quantification of sustainability; sustainable economic development and enterprise management. Among them, the articles related to digital governance published in this journal mainly discuss digital governance in environmentally sustainable development and the inter-relationship between digital governance and sustainable governance. In third place is Big Data & Society, which publishes articles related to digital governance, mainly including urban case studies of digital governance and cross-country comparative studies of data governance.

At the same time, the H index and G index can be used to comprehensively judge the journal contribution of digital governance research. The H-index, also known as the H-factor, is a measure of academic achievement and represents high citations. It can be used to evaluate the productivity and citation impact

of relevant publications. The G index is the derivative index of the H index, which can "average" highly cited articles to more articles to a certain extent. H index and G index have both advantages and disadvantages, so this paper tries to incorporate both indexes into the evaluation of journal contribution. The results show that if the H index is used as the evaluation criterion, the index value of Government Information Quarterly is 18, ranking first. Public Management Review and Sustainability rank second and third. If the G index is used as the ranking standard, the Government Information Quarterly is still ranked first, and Sustainability and Public Management Review is followed by second and third. Through the above three indicators, it can be seen that the number of relevant articles published by the Government Information Quarterly, G index, and H index rank first place in the theme of digital governance. Therefore, this journal is a core journal in the field of digital governance.

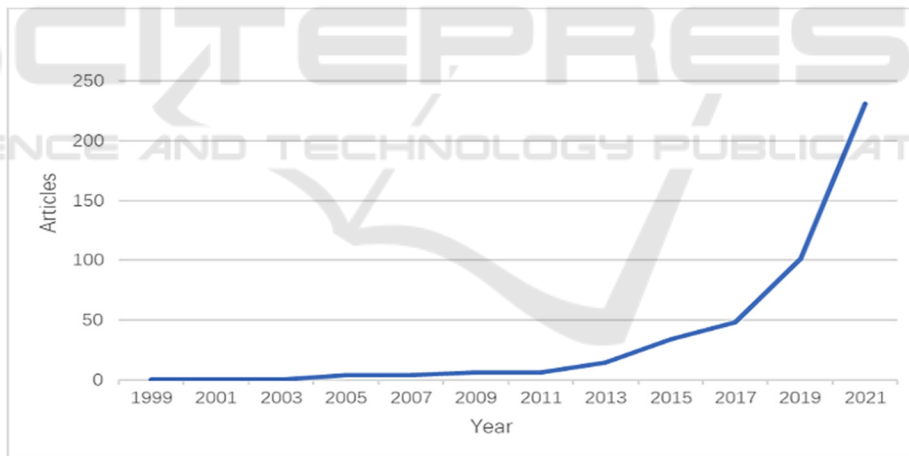


Figure 1: Annual Scientific production between 1999-2021 [Self-drawing].

Table 1: Ranking of publication sources based on the number of articles [Self-drawing].

Sources	G index	H index
Government information quarterly	30	18
Sustainability	17	10
Public management review	15	10
Information communication & society	12	6
Big data & society	10	8

Table 2: Ranking of publication sources based on G index and H index [Self-drawing].

Sources	Article
Government information quarterly	32
Big data & society	20
Canadian public administration-administration Publique du Canada	18
International journal of operations& production management	15
Information communication & society	14

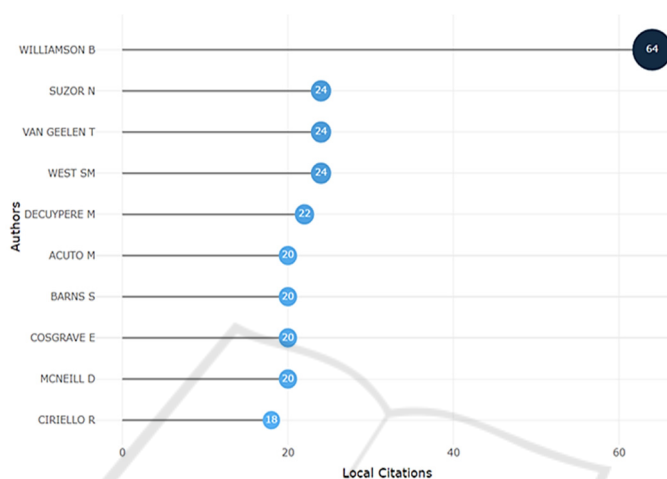


Figure 2: Most cited authors within the examined documents [Self-drawing].

5.3 Citation Analysis

Author-cited Analysis.

Citation analysis is used to study the most frequently cited authors and documents in the academic field. The number of citations generally represents the contribution of the author or literature to the academic field. In this paper, the "Most Relevant Authors" feature in the Bibliometrix toolkit is used to analyze the most frequently cited Authors in the digital governance domain, and the results are shown in Figure 2. It can be seen that WillamSon B is the most cited author in the field of digital governance, with the number of citations reaching 64 times. Suzor N, Van Gleen T, and West S M rank joint second, respectively, with the number of citations being 24 times.

Literature-citation Analysis.

The literature citation analysis method in the Bibliometrics toolkit is mainly implemented through local literature citation analysis and global literature citation analysis. This paper tries to use these two methods to conduct a citation analysis of the relevant literature on digital governance. At the same time, the

function of "Most Local Cited Documents" in the Bibliometrix toolkit is used to analyze the Most Cited local literature in the field of digital governance, and the analysis results are shown in Table 3. It can be seen that Williamson B's article "Digital Education Governance: Data Visualization, Predictive Analytics, and 'Real-Time' Policy Instruments" are the top citation with 16 citations (Williamson, 2016). This article focuses on a case study of digital education data systems, to explore the choice and application of policy tools for digital education governance. The author of the second most cited article is still Willamson B, which mainly discusses the emergence and application of digital governance technology in British public education (Williamson, 2015). The third to fifth articles focus on the value assessment of the governance legitimacy of online intermediaries (Suzor, 2018), the Web presence and improvement measures of educational digital governance (Barns, 2017), and the current status and challenges of digital infrastructure governance (Fung, 2015).

Table 3: Ranking of articles based on Global citations [Self-drawing].

Title	Author	Year	Global citations
Putting the Public Back into Governance: The Challenges of Citizen Participation and Its Future	Fung A	2015	365
Digital government evolution: From transformation to contextualization	Janowski	2015	190
The second wave of digital-era governance: a quasi-paradigm for the government on the Web	Margetts H	2013	164
What is platform governance?	Gorwa, R	2019	140
Big data in the policy cycle: Policy decision-making in the digital era	Hoechtl, J	2016	101

Table 4: Ranking of articles based on Global citations [Self-drawing].

Title	Author	Year	Local citations
Digital education governance: data visualization, predictive analytics, and 'real-time' policy instruments	Williamson B	2016	19
Governing software: networks, databases and algorithmic power in the digital governance of public education	Williamson B	2015	13
Digital Constitutionalism: Using the Rule of Law to Evaluate the Legitimacy of Governance by Platforms	Suzor n	2018	12
Diagrams of Europeanization: European education governance in the digital age	Decuypere M	2016	11
Digital Infrastructures and Urban Governance	Barns S	2017	10

Fung A's article "Bringing the Public Back to Governance: The Challenge of Civic Engagement and Its Future" is ranked number one in the world's most cited literature (Fung, 2015). This paper mainly discusses the value orientation of participatory governance. It also highlights the challenges to participatory governance posed by the development of digital technologies and the growing demands of citizens for personalized governance. Janowski's article, which presents a phased model of the evolution of digital government and provides some evidence to explain the phased model, comes in second (Janowski, 2015). The third to fifth literature mainly discusses the governance model in the digital era (Margetts, 2013), the interdisciplinary research paradigm of platform governance (Gorwa, 2019), and ICT for policy decisions (Hoechtl, 2016).

Citation analysis only shows the contribution of authors and documents in the field of digital governance research to the academic field. However, as a dynamic research system, the digital governance research field needs to understand the knowledge structure of digital governance. Knowledge structure shows research structure and dynamic presentation in academic research. At the same time, the knowledge structure is helpful to determine the main theme of digital management and explore the dynamic changes between theme analysis, in order to further understand the digital governance research in the field of

knowledge structure, the next will be led by the author, literature analysis, frequency analysis, theme evolution analysis, to further explore digital governance research field.

5.4 Co-Citation Analysis

Author Co-Citation Analysis

The basic assumption of the author co-citation analysis method is: that when the literature of two authors is cited by the literature of the third author at the same time, then there is a co-citation relationship between the two authors. The higher the frequency of co-citation between two authors, the closer the academic relationship between scholars is. Then, by clustering, multi-dimensional scale analysis, and other statistical methods, the author identifies the scientific community in the academic field. This paper visually presents relevant literature on digital governance through co-citation analysis of Vosviewer software, and the results are shown in Figure 3. Among them, node size represents the frequency of authors' common citations, and different colors of nodes represent different clusters formed by authors' research.

The co-citation analysis based on the authors reveals four clusters formed by digital governance research. As can be seen from Figure 3, the co-cited sources of the cluster are public institutions represented by the European Union and the European

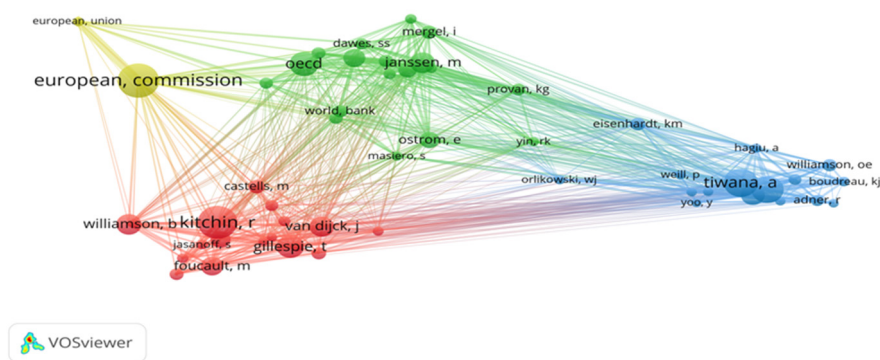


Figure 3: Author co-citation analysis [Self-drawing].

Commission. The cluster mainly involves the formulation of digital governance regulations, the improvement of digital governance policy documents, and the formulation of national data security regulations and problem governance. The second basic cluster is formed around Janssen M, Dunleavy P, and other authors. The research on citizen participation, citizen empowerment, blockchain governance, digital platform governance, and governance in the digital age is the core of this cluster. The core authors of the third cluster mainly include Kitchin R and Williamson B. This cluster mainly discusses smart city governance and smart education governance, and the fourth cluster mainly discusses the governance application and improvement of information technology.

Literature Co-Citation Analysis

The "literature co-citation" function in Citespace software is used to conduct knowledge graph analysis on the paper texts collected by digital governance research. After entering the software and selecting the project, the time and slice parameters are adjusted, and the clipping function and path-finding function are canceled. After selecting "Reference" as the analysis target, click visualization. After the data visualization is completed, the Citespace menu bar is used to adjust the size of labels and lines, and the image position is adjusted to perform clustering processing. The TF-IDF algorithm is chosen for clustering processing because it has obtained a general consensus in academia. After that, satisfactory maps are obtained by clustering labels and algorithms, and finally, four digital governance literature clusters are obtained by literature co-citation analysis. The first type of literature cluster is named "Public Health Data".

The literature in this field focuses on the risks and challenges faced by public health governance in the era of big data, as well as the countermeasures. The second kind of literature cluster mainly discusses the

influence and function of the digital economy on social governance and emergency management. Niu, FJ, for example, based on the survey of four different types of employees, adopts a structural equation model approach to explore the role and mechanism of the digital economy on socio-economic reform and governance (Niu, 2022). The results show that there is a certain degree of relationship between the digital economy and the social governance system, and the sustainable digital economy system confirms the mediating effect between them. With this revelation, the government should grasp the connection between digital economy and governance, and promote digital economy and digital governance level. The third kind of literature cluster mainly focuses on data governance. The main contents of this research focus on the core ownership, nature, rights, and interests of data and the discussion of many rights and obligations in the process of digital governance, such as personal privacy, data property rights, and digital sovereignty. The fourth type of document clustering is named "joint research agenda", this topic mainly discusses the constitutional governance platform management, digital and other emerging research fields of digital governance, needs joint efforts of the scholars to develop related technical framework, to promote the emerging research paradigm in the field of digital management to further improve, further enrich the research theory.

5.5 Word Frequency Analysis

Word frequency analysis is a common statistical analysis technique used in information retrieval and text mining, which is used to analyze the number of repetitions of a word in a text or material database. Word frequency analysis helps to clarify the key themes emerging from digital governance research. In this study, the number of words in the keyword module of

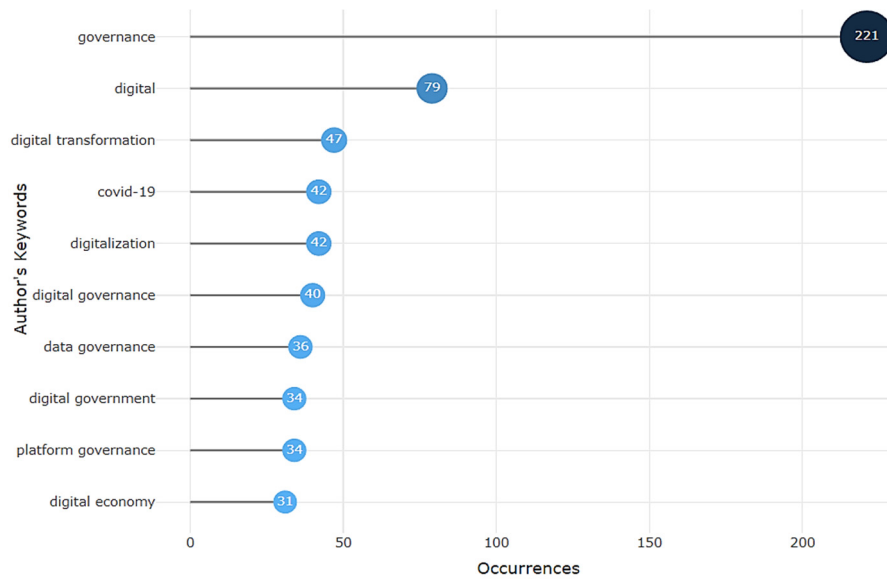


Figure 4: Word frequency analysis [Self-drawing].

the paper is selected as the measurement index, because the keyword module is more suitable for the topic expressed in the paper, so the selected words are more representative. Therefore, through the Bibliometrics toolkit in R language, the word frequency analysis function is used to conduct word frequency statistics for the keyword module of the relevant literature on digital governance and the results are shown in Figure 4. It can be seen that:

The word "governance" appears the most, and the number of occurrences reaches 221 times. Digital governance, in the final analysis, is to achieve reasonable and effective governance of digital scenes, digital business forms, digital economy, and other relevant digital scenes through digital technologies such as big data, artificial intelligence, and blockchain. The terms "technology" and "technological transformation" rank second and third. It can be seen the importance of the application of digital value technology. Digital management is inseparable from the universal application of technology. Digital management is equivalent to management with technology to some extent. Through the application of relevant digital technologies, governance institutions promote the modernization, intelligence, and automation of governance models.

The term "COVID-19" ranks fourth the number of times, which reflects the academic community's widespread concern about the optimization and improvement of the global digital governance model. For instance, Lee and other scholars discuss the specific role of digital governance in the process of supporting public crisis management in the context of the

COVID-19 pandemic by integrating the relevant analysis framework through the case study of South Korea (Lee, 2020). The academic discussion on COVID-19 and digital governance provides beneficial enlightenment for the governing bodies to apply digital governance technology such as health codes to the practice of public crisis.

"Data governance" is even more frequent, appearing 36 times. Human society has entered the era of big data, and data elements have become the most critical digital resource. The main content of digital governance research focuses on the core ownership, nature, rights, and interests of data, and discusses many rights and obligations in the process of digital governance, such as personal privacy, data property rights, digital sovereignty, and so on. Therefore, many scholars have discussed the connotation and system improvement of digital governance from the perspective of data.

5.6 Strategic Map Visualization Analysis

On the basis of word frequency analysis, the visual analysis of strategic maps is helpful to better understand the research topic of digital governance. The strategic map is composed of two dimensions: centrality and density. Centrality is a measure of the importance of a topic in a research field, and a strategic density map is drawn by centrality and density, and the "thematic map" function is realized by the Bibliometrics toolkit function. The result is shown in Figure 5.

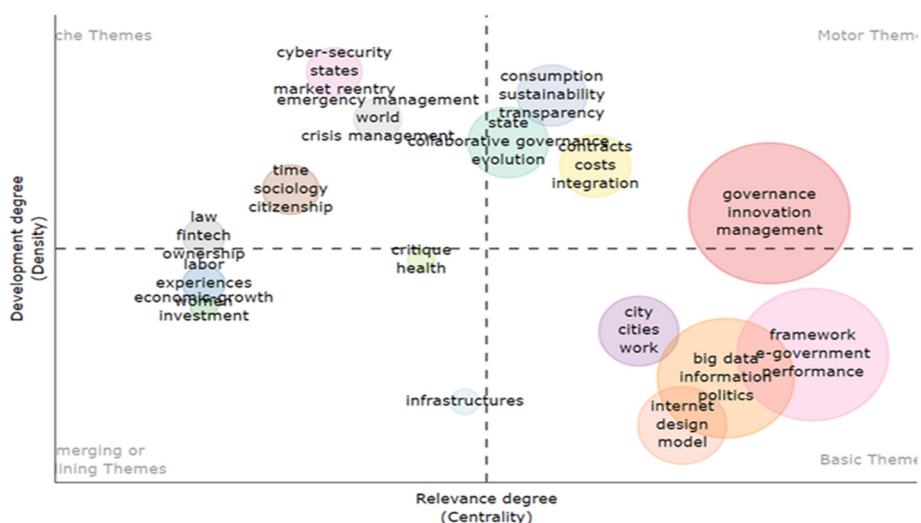


Figure 5: Strategic map visualization analysis [Self-drawing].

The topic located in the fourth quadrant of the strategy diagram is called the core topic, and it is the core of all research topics. The core themes of digital governance mainly include "digital governance innovation", "e-government", "big data governance", "digital city", "Internet platform governance" and other related topics. Themes in the second quadrant of the strategic map are also known as "mobile themes". The theme of the movement represents the development theme in the field of digital governance, which is of great significance to the research of digital governance. "Digital governance innovation" and "digital cooperative governance" are the movement themes of digital governance. The topics covered by "digital governance innovation" mainly include "governance", "innovation" and "management", while the topics covered by cooperative governance hotspots include "state", "cooperative management", "document analysis" and "evolution". The topic density of the ecological theme is high, but the centrality is low. These issues have little impact in areas where internal links have been established, but their external importance is negligible. "Cyber security" is one of the ecological themes of digital governance, mainly involving global security digital governance, cyber security digital governance capacity building, digital trade and so on.

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Emerging or declining topics have low density and relevance, and may be new or disappearing topics. Topics in this category include "digital infrastructure", "digital workforce", "Digital economy and digital investment", "smart healthcare", etc.

The visual analysis of strategic maps helps to understand hot themes, movement themes, ecological themes, and emerging or declining themes of digital governance, and plays an important role in understanding the core concepts of key themes of digital governance. However, from the time dimension, the specific situation of the conceptual structure change in the digital governance domain is not clear. Therefore, this paper will introduce the theme evolution analysis method to analyze the evolution of the digital governance theme in chronological order and discuss the emergence, development, and evolution process of the digital governance theme in detail.

5.7 Theme Evolution Analysis

Through visualization tools such as the Sankey diagram, the topic evolution analysis of the digital governance research field is carried out. The reason why the Sankey diagram is used for topic evolution analysis is that the Hat Sankey diagram can effectively describe the flow of one set of data to another, and can also reflect the size of the specific data flow through the block, suitable for topic evolution analysis. At the same time, this way can be proved by dividing and comparing different periods. Using the thematic evolution function in the toolkit of the Bibliometrics package in R language and the time function for time slicing, 1999 and 2010 are used as the starting point and compound point of the research to analyze the

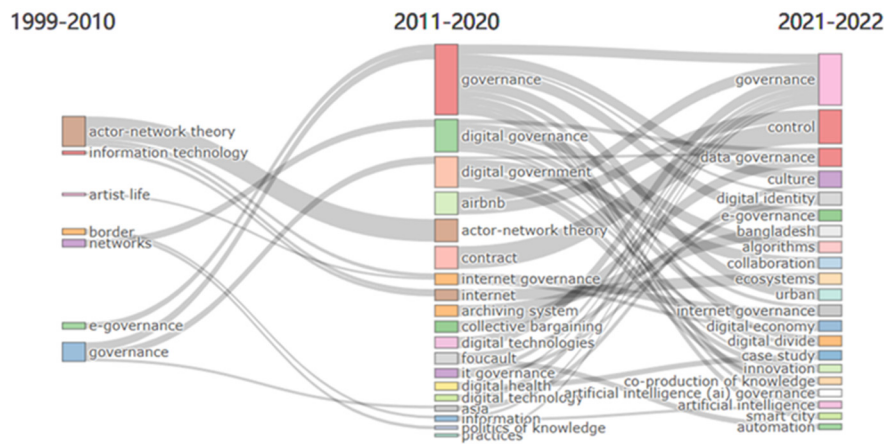


Figure 6: Theme evolution analysis [Self-drawing].

theme evolution of the collected digital governance-related literature. The results are shown in Figure 6.

In the first period, from 1999 to 2009, "actor-network theory" is the biggest theme in the development of this field. The actor-network theory provides the basic theoretical support for digital governance research and the participation mode of governance subjects. For example, other topics include "information technology", and "e-government. The reason for the small number of topics is mainly that the research on digital governance was still in its infancy at that time.

In the second period, from 2009 to 2019, more research topics appear in the field of digital governance, and relatively important research topics appear in this period. Digital government is one of them. In addition, during this period, many new research topics appeared in the field of digital governance, such as algorithm management, application of algorithm technology, discussion of algorithm discrimination, and construction of algorithm supervision model. The emerging themes also include digital health governance and digital cooperative governance, etc. These emerging themes mark the research trend and research frontier of algorithmic governance.

In the third stage, the research topics of digital governance have further changed, and many new research topics have emerged, such as the phenomenon of convergence in digital governance, smart agriculture, data governance, Internet platform governance, digital governance under COVID-19, digital trade, digital finance, etc. At the same time, the basic themes. That is, the themes of digital government, e-government, and governance have been further deepened and developed, the research content has been continuously expanded and the research results have been constantly fruitful.

6 CONCLUSION

Based on the Bibliometrix toolkit in R language, Citespace, and Vosviewer software, this paper discusses the contribution of authors, literature, and journals in the research of digital governance to the performance of this research field. At the same time, it discusses the knowledge structure of the field of digital governance through the co-citation analysis of authors and literature. Preliminary results are obtained:

Government Information Quarterly is the core journal in this field, and this journal contributes 32 relevant articles to the field of digital governance research. These articles mainly discuss the choice of the digital governance model and the case analysis of digital governance countries and cities. Other core journals in the field of digital governance research include Sustainability, Public Management Review, Big Data & Society, etc. After that, the core authors and literature of digital governance research are identified through citation analysis. It is found that Williamson B, Suzor N, Van Gleen T West S M, and others are the core authors in this field.

Through author co-citation analysis and literature co-citation analysis, the knowledge cluster of digital governance research is deeply analyzed. At the same time, the rise and fall of digital governance research themes are understood through theme evolution analysis. The results show that the phenomenon of citizen collaboration in digital governance, smart agriculture, data governance, and platform governance become the frontier directions of digital governance research.

At the same time, there are also the following deficiencies in the research process to be improved; First of all, bibliometric technology itself has some

shortcomings. Bibliometric technology can only provide a snapshot of the research field. Researchers need to combine context, discourse analysis, and narrative analysis to have a more detailed understanding of the research content. The second is the limitation of data sources. Core journals in English included in the Web of Science require high impact factors, which may exclude good works from newly published journals. Based on the above research deficiencies, the deficiencies of bibliometric analysis can be improved through text narrative analysis, meta-analysis, and other research methods. At the same time, the index scope can be expanded to include more and higher quality digital governance articles in the research scope.

Williamson, B., Governing software: networks, databases and algorithmic power in the digital governance of public education. *Learning Media and Technology*, 2015. **40**(1): p. 83-105.

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