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Article

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Review

Tracing the Evolution of E-Government: A Visual Bibliometric Analysis from 2000 to 2023

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Abstract: In the continuously evolving field of E-government, understanding the breadth and depth of academic research is crucial for advancing governmental digital transformation and policy development. This study employs visual bibliometric analysis, using the Web of Science database to map the evolution trajectory of E-government research from 2000 to 2023. By utilizing CiteSpace for a comprehensive examination of 4536 academic articles, this paper outlines the growth patterns and thematic evolution within the field. The development of the E-government field is delineated into four distinct phases: the budding period (2000–2003), the bottleneck period (2004–2014), the development period (2015–2018), and the growth period (2019–2023), which are each marked by unique thematic shifts and technological advancements. The research results reveal the transformation of research focus in different periods, from the initial focus on the technological means and the electronic transformation of government services, moving on to more complex issues such as E-government acceptance and government transparency and corruption, and ultimately to the current focus on innovation and smart cities. In addition, the paper also clarifies that the research boom that began in 2019 is driven by technological innovation opportunities, the improvement in infrastructure, and multidisciplinary research. By depicting these developmental stages and emerging trends, this study not only unveils past academic efforts but also forecasts future research directions, thereby providing valuable insights for researchers and policymakers aiming to understand and implement effective E-government strategies.

Keywords: E-government; bibliometric analysis; COVID-19

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1. Introduction

Promoting and implementing E-government is a longstanding trend of national governments due to its significant benefits (Nam 2014), such as improving the public's trust in the government (Jameel et al. 2019), improving the public service quality (Osei-Kojo 2017), reducing administrative costs, etc. (Muñoz et al. 2018). Therefore, scholars and practitioners concur that the vigorous promotion of E-government can enhance the government's functionality and efficiency, leading to considerable interest in this field (Hung et al. 2006; Tonetto et al. 2023).

Research on E-government has grown tremendously thanks to the efforts of numerous researchers in various fields (Heeks and Bailur 2007; Ramzy and Ibrahim 2022). Tsai and Wu (2010) point out that integrating current knowledge is the key to creating new knowledge. Nevertheless, with the rapid growth in the range of disciplines and the volume of papers concerning E-government research, it has become a major bottleneck for scholars to stay in line with the latest developments in E-government, as well as to understand the focus of current research in a comprehensive and simplified manner (Ramzy and Ibrahim 2022).

To address this dilemma, bibliometrics offers a valuable mathematical and statistical technique for analyzing literature, providing an invaluable tool for understanding current

knowledge and developments in any research field (Chen et al. 2017; Wang et al. 2016). Actually, the bibliometric method has been widely used in various research areas, such as information science (Hou et al. 2018), management (Lulewicz-Sas 2017), and medicine (Liao et al. 2018). Numerous researchers have employed bibliometric methods to provide an extensive understanding of both the focus and the knowledge evolution within the field of E-government (Almeida 2014; Dias 2014, 2019).

However, there are some limitations to these studies. First of all, most studies have primarily focused on identifying the hot topics within the E-government field, yet they have overlooked how these research themes have evolved over time. Secondly, these studies are not sufficient to reflect the existing knowledge composition. Especially for the latter, the latest overall review of the knowledge in this field was produced before 2019 (Ramzy and Ibrahim 2022). Nevertheless, the COVID-19 pandemic, which began in 2019, affects various areas (Lin et al. 2023; Strielkowski et al. 2022; UN 2022). During the pandemic period, the governments of the world were forced to accelerate the process of E-transformation in response to the crisis (Agostino et al. 2021). In a word, the pandemic has changed our lives and thoughts, bringing Information and Communication Technology (ICT) to the forefront of life (Barnes 2020). This change could potentially accelerate electronic transformation in the future (Barrutia and Echebarria 2021). As noted in a past study, this crisis has not only created opportunities for innovation (e.g., the development of digital technologies) but also brought in new issues (e.g., norms governing the use of emerging technologies) and highlighted old issues (e.g., the inadequacy of digital infrastructures) (Gkeredakis et al. 2021). Unfortunately, it was unclear what impact this particular period has exerted on current E-government research. Therefore, it is necessary to re-analyze the knowledge in this field to update our understanding of it.

For the purpose of bridging this research gap and providing an updated, comprehensive reference for researchers and policymakers, this paper employs visual bibliometrics and the CiteSpace tool to analyze E-government-related publications in the Web of Science (WOS) database from 2000 to 2023. The paper analyzes and draws corresponding knowledge maps for annual publication volume, co-occurrence network, keyword clustering, and subject categories with the strongest citation burst for research in the field of E-government. This study investigates several aspects by analyzing a series of knowledge graphs and relevant data, including the following: (1) What are the key evolutionary trends and major shifts in E-government research over time? (2) How has the COVID-19 pandemic influenced the progression of E-government research, and has it transformed the thematic focus within the field? (3) What are the most promising research topics that are expected to stand out in the future? The primary contribution of this paper is the creation of a comprehensive, up-to-date, and timeline-oriented framework that elucidates the evolution of knowledge in the E-government sector, designed for use by both researchers and governmental practitioners. This framework is pivotal in underpinning subsequent academic studies and informing the development of policies.

2. Literature Review

The bibliometric method offers a systematic quantitative approach to studying academic literature. It enables the tracking of knowledge breakthroughs and advancements within a specific field over time (Van Raan 2005). The bibliometric method can be used in titles, keyword lists, publication abstracts, or the entire citation record, aiding in the identification of particular topics and categories assigned to publications (Lulewicz-Sas 2017). One of the most notable advantages of bibliometrics is its capacity to allow researchers to delve into a particular field of study, offering them valuable insights (Liao et al. 2018).

Several studies have employed bibliometric analyses within the E-government domain. The overview of these studies has been summarized in Table 1. For example, Almeida (2014), employing the WOS database, conducted an extensive analysis of E-government research from 1986 to 2012, encompassing 4225 documents. The core findings of this research include a quantified overview of E-government academic production, the identification of leading

countries, authors, and institutions, and an analysis of the temporal evolution of literature and citations.

Table 1. Overview of studies applying bibliometrics to the field of E-government.

Article	Data Base	Time Frame	Number of Documents	Timeliness (Include 2019–2023)	Timeline-Based Analysis	Research Focus for Different Time Periods
(Rodríguez Bolívar et al. 2016)	WOS	2000–2012	826	-	√	-
(Arias et al. 2019)	WOS	2002–2017	161	-	-	-
(Dias 2014)	Scopus	2003–2013	48	-	-	-
(Dias 2019)	Scopus	2003–2017	1129	-	-	-
(Cheng and Ding 2012)	WOS	2000–2012	2232	-	√	-
(Almeida 2014)	WOS	1986–2012	4225	-	√	-
(Ramzy and Ibrahim 2022)	DGRL, Scopus	2000–2019	21,320	-	√	√
This research	WOS	2000–2023	4536	√	√	√

"√" indicates the presence of the above characteristics. "-" indicates the absence of the above characteristics.

Subsequently, Rodríguez Bolívar et al. (2016) utilized the WOS database to analyze 826 documents spanning from 2000 to 2012. The study's central discoveries underscore the inadequacies in theoretical and model development within the E-government domain, as well as the discrepancies in scientific output impact between developing and developed nations. In the same temporal framework, Cheng and Ding (2012) also conducted a quantitative study through WOS on 2232 documents from 2000 to 2012, identifying research hotspots in electronic government, such as cross-sectoral collaboration and security design, and pinpointing performance evaluation as a key research frontier.

Dias (2014) analyzed Portuguese E-government research covering 48 documents from 2003 to 2013 using the Scopus database. The study revealed significant room for enhancement in research themes and methodologies within Portugal's E-government scholarship. Expanding the scope, Dias (2019) assessed Ibero-American E-government research from 2003 to 2017 through Scopus, examining 1129 documents. This investigation recognized the most productive and influential researchers, institutions, and countries, along with patterns of international collaboration.

Returning to the WOS database, Arias et al. (2019) explored 161 documents from 2002 to 2017. Their study synthesized a categorization of academic subfields within E-government and identified 40 seminal works that have a profound impact on current academic discourse.

Lastly, Ramzy and Ibrahim (2022) conducted one of the most extensive surveys using the Digital Government Reference Library (DGRL) and Scopus databases, covering the years 2000 to 2019, and analyzed 21,320 documents. Their research revealed a 21.50% annual growth rate in E-government studies and discovered that open access documents received higher average citations compared to others, with English prevailing in both the production and influence of E-government.

However, the existing bibliometric analyses have manifested two major shortcomings in capturing the evolution of this field. First, due to the rapid evolution of the E-government field, these studies may no longer encompass the most recent composition of knowledge. To our knowledge, no bibliometric studies have incorporated E-government literature from post-2019 into their analyses. Notably, this period was marked by the global spread of COVID-19 and its profound impact on various sectors (Ma and Kwon 2021; Roper and Turner 2020). The United Nations (UN) E-government survey in 2022 (UN 2022) highlighted that this pandemic improved the awareness of the importance of E-government. Regrettably, there is currently a lack of understanding of the knowledge structure during this critical period, particularly regarding whether this crisis will reshape research themes in the field.

Moreover, previous bibliometric analyses have attempted to trace the development of E-government through a timeline-based approach; most of these discussions have been limited to the basic metrics of document volume or citation counts. Only a few studies have delved into the evolution of research topics over the timeline. This oversight underscores an urgent research gap. Namely, there is an urgent need for an up-to-date, comprehensive, timeline-based analysis of current E-government-related knowledge. This analysis would be instrumental in crafting a vivid and accessible vista of the domain's knowledge evolution, crucial for guiding upcoming research endeavors and emerging policy frameworks. Thus, this paper employed a bibliometric method to re-review the research in the field of E-government with the aim of providing the most comprehensive and updated guide to future researchers and policy makers.

3. Method and Research Data

3.1. Data Gathering and Data Cleaning

In this paper, visual bibliometric analysis methods were used, mainly in terms of annual publication volume and critical keywords.

Data quality is crucial for citation-based analysis, which involves selecting an appropriate data source and cleaning the bibliographic metadata (Chen et al. 2019). The bibliometric data used in this paper were collected and cleaned in the following ways.

First, this study used the Science Citation Index Expanded (SCIE) and Social Science Citation Index (SSCI) databases in WOS as its data source. WOS is widely recommended for bibliometric analyses (Cui et al. 2018; Guo et al. 2019; Liao et al. 2018; Wan et al. 2023; Zhu and Hua 2017), with SCIE and SSCI being the most commonly used and representative databases (Liao et al. 2018; Liu and Liao 2017; Yu and Liao 2016). This approach ensures the reliability and representativeness of the data.

Secondly, previous studies (Cheng and Ding 2012; Dias 2014, 2019; Ramzy and Ibrahim 2022) were mentioned to identify relevant research terms, such as "digital era government" OR "digital-era government" OR "digital government" OR "egovernment" OR "e-government" OR "electronic government" OR "smart government" OR "open government" OR "digital era governance" OR "digital-era governance" OR "digital governance" OR "e-governance" OR "egovernance" OR "electronic governance" OR "smart governance" OR "open governance". These pertinent research terms were extracted from topics, which entailed identifying papers that include these words in their keywords, abstracts, and titles.

Thirdly, the period was confined to 2000–2023, allowing for any field of study but only including papers in English. Notably, although the document type was limited to papers, the retrieved sample included two retracted papers. The two papers were manually excluded.

In addition, in order to obtain more accurate analysis results, some synonyms were merged during the analysis process, especially abbreviated keywords such as "e government", "e-government", "e-government", and "egovernment" were merged into "electronic government" and plural forms such as "smart cities" was merged into "smart city". It is worth noting that although the concepts of digital government and E-government are similar, some researchers believe that the concept of digital government is more macro than that of E-government (Ravšelj et al. 2022). Therefore, this article does not merge digital government and E-government as synonyms.

Each downloaded paper was converted and stored as a plain text file for further data processing and analysis.

3.2. Citespace Tool

This study employed CiteSpace, a highly functional and efficient software for bibliometric analysis, to conduct bibliometric analysis on the retrieved documents (Chen et al. 2019; Cheng and Ding 2012). CiteSpace was based on Java as a tool for visualization and bibliometric analysis methods (Xu et al. 2022). After years of continuous

development and enhancement, the software has become widely recognized as one of the most popular tools for visual bibliometric analysis (Shao et al. 2022; Xu et al. 2022).

Researchers have observed that this tool is highly effective in identifying and visualizing clusters of related research topics and the co-citation relationships between them (Chen 2006). This significantly aids in understanding turning points and transformations within research topics in a given field. Since CiteSpace has many customizable visualization options, which allow researchers to explore their data using different perspectives and approaches (Kumar et al. 2023). In this paper, the CiteSpace tool has been used to perform keyword co-occurrence analysis, cluster analysis, and citation burst analysis to explore the composition and evolution of knowledge in the field of E-government.

Keywords are crucial in encapsulating the central themes and essence of a paper. Keyword co-occurrence analysis uses keywords as nodes to explore hot research areas within different periods (Jia et al. 2023). In the knowledge map of keyword co-occurrence, larger node labels indicate higher frequencies of the corresponding keywords. The links represent the co-occurrence relationship, and their widths reflect the strength of co-occurrence between the keywords (Xu et al. 2022).

In order to offer a more intuitive and understandable overview of the key elements and proportions of the current research, complex keywords are classified and condensed by using keyword clustering (Shi et al. 2023). While three algorithms can compute the clusters, the log-likelihood ratio (LLR) algorithm is considered more practical and less repetitive, making it the recommended first choice (Ren et al. 2023; Zang et al. 2022). Moreover, the assessment of network structure and cluster definition can be based on two metrics from CiteSpace: the average profile value (S-value) and the module value (Q value). In other words, these metrics can be used to assess the effectiveness of the knowledge map of clusters. Normally, if the Q value is above 0.3 and the S value is above 0.5, the cluster can be deemed reasonable, and the divided community structure is significant (Chen et al. 2022; Jia et al. 2023).

Moreover, the dynamic characteristics of a particular field are reflected in the increased citation frequency of literature related to that field. This increase is referred to as a "citation burst" (Zhao et al. 2023). As Abbas et al. (2019) pointed out, tracking the time trends of citation bursts can identify important research areas at specific points in time. In the citation burst map, the red line indicates the burst phase, and the dark blue line indicates the research phase (Zhao et al. 2023).

Previous research has recommended the Web of Science database as the main data source for this tool (Chen et al. 2022). This is consistent with the approach taken in this paper. In addition, the main program steps of CiteSpace include time slicing, thresholding, modeling, pruning, merging, and mapping (Chen 2004). After importing the data into CiteSpace, we deleted duplicate data, followed this recommendation, and set the following parameters: (1) the time limit was 2000–2023; (2) the source of words was set to keywords plus, author keywords, abstracts, and titles; (3) the pruning setting was set to pathfinder and pruning merge network; (4) 50 papers with the highest number of citations were selected for each slice.

Ultimately, 4536 papers were chosen for the analysis. The data gathering and data cleaning process are shown in Table 2.

Table 2. Data gathering and data cleaning process (retrieved on 6 March 2024).

Indexes = WOS Core Collection;		
Namely = SCIE and SSCI;		
Stage	**Item**	**Number of Documents**
1	Search term: TS = ("digital era government" OR "digital-era government" OR "digital government" OR "egovernment" OR "e-government" OR "electronic government" OR "smart government" OR "open government" OR "digital era governance" OR "digital-era governance" OR "digital governance" OR "e-governance" OR "egovernance" OR "electronic governance" OR "smart governance" OR "open governance")	5295
2	Time filter: 2000–2023	5173
3	Document type filter: only paper (excluding retracted publication)	4717
4	Language filter: English	4572
5	Remove duplicates	4572
6	The parameters used in CiteSpace for this study were as follows: 1. Time slice: 2000–2023. 2. Term source: keywords plus, author keywords, abstract, and title. 3. Pruning method: pathfinder and pruning the merged network. 4. Selection of 50 most cited items per slice.	4536
7	Data cleaning (synonym consolidation) was undertaken as follows: Merged "PEOPLES R CHINA" into "CHINA". Merged "e government", "e-government", "e-government", and "egovernment" into "electronic government". Merged "e governance", "e-governance", and "egovernance" into "electronic governance". Merged "d government", "d-government", and "dgovernment" into "digital government". Merged "digital-era government" into "digital era government". Merged "digital-era governance" into "digital era governance". Merged "local governments" into "local government". Merged "smart cities" into "smart city". Merged "web 20" into "web 2.0". Merged "ENGLAND" and "SCOTLAND" into "UNITED KINGDOM".	4536

4. Results

4.1. The Annual Volume of Paper Publication

Figure 1 shows the trend based on the annual volume of paper publication. Similar to a previous study (Ramzy and Ibrahim 2022), the results shown in Figure 1 indicate that the focus on E-government began in 2000, with a rapid increase in the number of papers published, and reached a peak in 2003. This marks the initial stage of E-government research.

Compared to 2003, the number of papers began to decline in 2004. The number of papers per year has fluctuated and grown slowly in the 14 years since 2004, indicating that research in the field of E-government has passed the initial stage of germination and entered the next period. According to Jiang et al. (2022), the 2014 United Nations E-government Survey: The Future We Want in E-government showed that governments had begun to pay attention to open data and began to address the opportunities, dilemmas, and plans for open government data. This led many researchers to pay attention to this field and triggered a new round of research from 2015 to 2018. This means that the focus of research before and after 2014 may have changed.

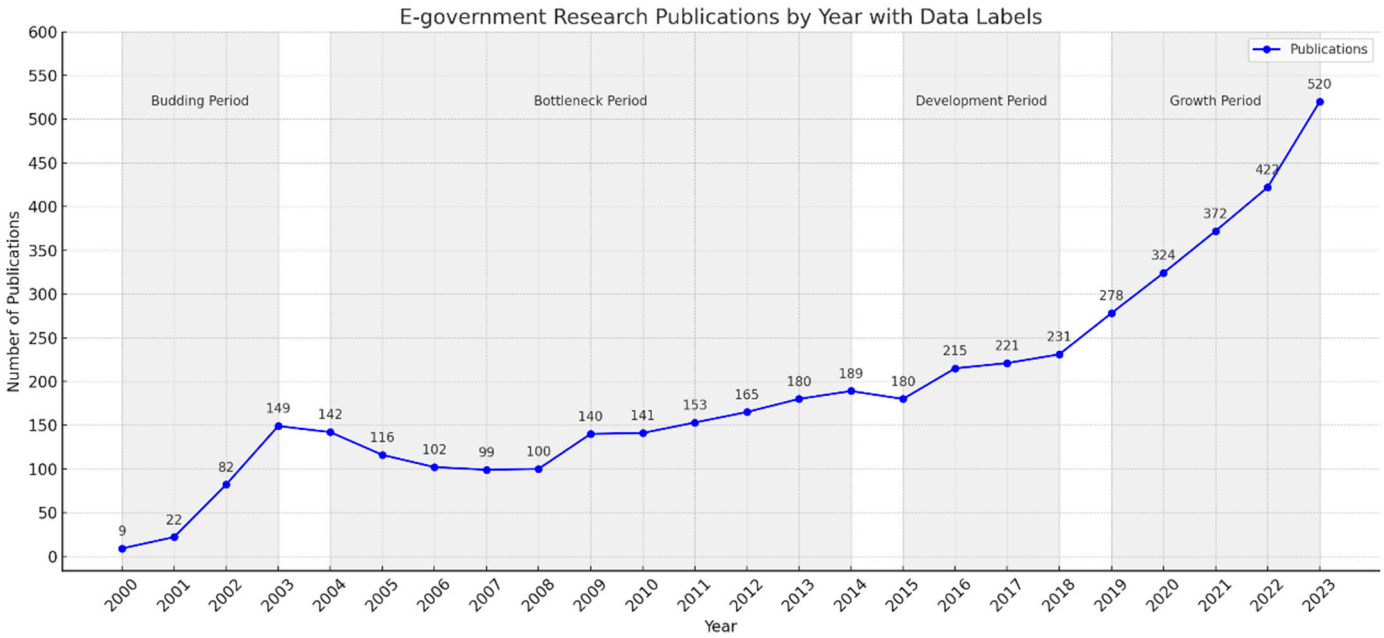

Figure 1. The annual volume of papers publication.

Therefore, in this paper, the research from 2004 to 2018 is divided into two periods: 2004–2014 and 2015–2018. In the second period (2004–2014), the number of papers published in this period remained relatively stable, with some fluctuations, and the overall growth was slow. The number of publications fluctuated between 100 and 153, with an annual growth rate of about 2.8%. In the third period (2015–2018), the number of papers published began to rise slowly, with an annual growth rate of 3.8%. However, in general, the two periods were limited by the lack of innovative technologies and methods, as well as infrastructure, so research progress was slow.

The final phase spans from 2019 to 2023. During this period, breakthroughs in new technologies related to E-government, such as AI, have occurred to a certain extent, and supporting policies have also been improved. Additionally, under the threat of the COVID-19 pandemic, governments worldwide were compelled to accelerate their digital transformation. Various new technologies were experimentally applied in the provision of E-government services. Benefiting from technological advancements and improved infrastructure, the number of studies during this period experienced exponential growth. The annual growth rate during this phase was approximately 16.8%.

In summary, this paper broadly divides the development of the E-government field over the past 23 years into four periods. Based on the different growth trends of articles in these four periods, this article will name the four periods as the budding period (2000–2003), the bottleneck period (2004–2014), the development period (2015–2018), and the growth period (2019–2023).

The results show that the current research is increasing each year, and the trend is still upward, which means that the E-government research area may still be in an immature stage and still needs the continued attention of researchers. As noted by Wirtz and Daiser (2018), the field of E-government will be an ongoing, open research environment that will continue to provide multifaceted research opportunities. The results of this study corroborate this point.

Interestingly, the findings reveal that the number of studies in the field of E-government began to grow exponentially in 2019, showing a 20.9% increase compared to 2018. Surprisingly, the rapid growth in 2019 may not be primarily attributed to the COVID-19 pandemic. This is because, although the crisis began in late 2019, it was not officially classified as a pandemic by the International Health Organization until March 2020, marking it as a global crisis (WHO 2020). Therefore, we believe that the surge in E-government research

starting in 2019 can be attributed to the opportunities for innovative technologies and the improvement of infrastructure, such as the advancement of artificial intelligence (AI) technology, as well as the emergence of a supportive policy framework.

4.2. The Network of Keywords Co-Occurrence

To draw the knowledge map of keyword co-occurrence, "Keywords" is selected as the node parameter for analysis. To more thoroughly investigate the characteristics of the primary research focus across different periods, as well as their changes, this paper follows the four different periods classified in the previous section through keywords co-occurrence analysis. Figure 2 illustrates the keyword co-occurrence network for the budding period (2000–2003), which consists of 91 nodes and 117 connecting links. Similarly, Figure 3 shows the network for the bottleneck period (2004–2014), with 399 nodes and 2477 connecting links. Figure 4 shows the network for the development period (2015–2018), with 301 nodes and 1679 connecting links. Figure 5 illustrates the network for the growth period (2019–2023), with 421 nodes and 2840 connecting links.

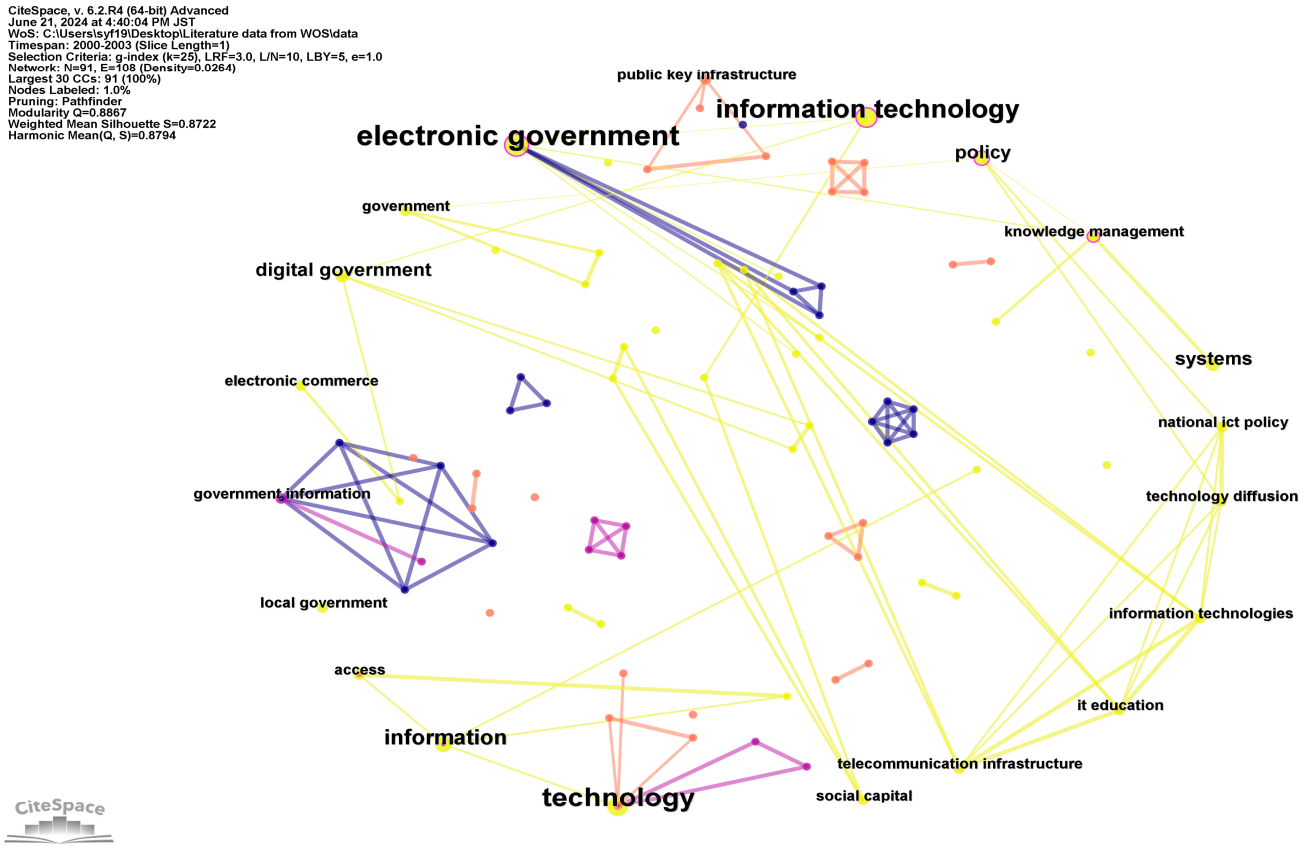

Figure 2. Keyword co-occurrence network during the budding period (2000–2003).

Each node in the analysis is a specific keyword. The trends in the number of nodes indicate a nuanced evolution in research focus over time. During the bottleneck period (2004–2014), despite the stable output of publications annually, the research exhibited increased depth and diversification when compared to the earlier period (2000–2003). Subsequently, in the development phase (2015–2018), there was a contraction in the variety of keywords, suggesting a refinement of the research agenda. Some keywords were merged or excluded. However, during this period, the annual volume of publications experienced a gradual increase. The growth period (2019–2023) marked a significant surge in both the number of publications and keywords, highlighting the expanding scope and burgeoning potential of the field.

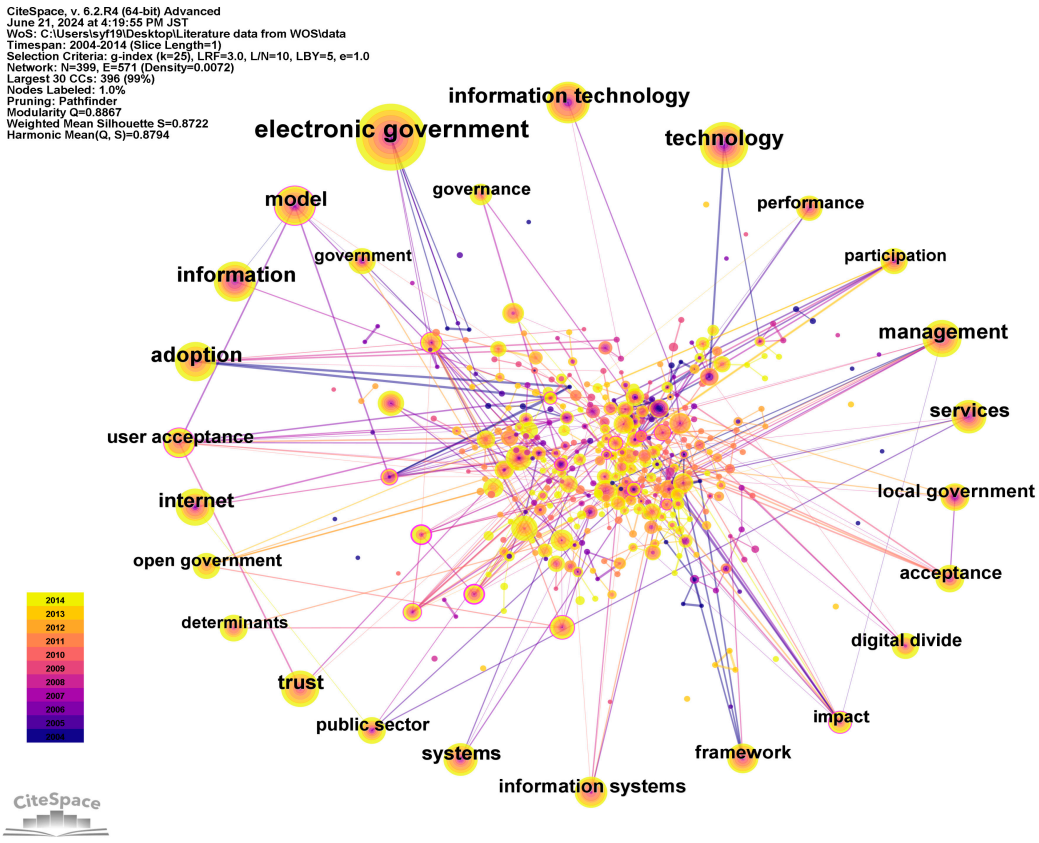

Figure 3. Keyword co-occurrence network during the bottleneck period (2004–2014).

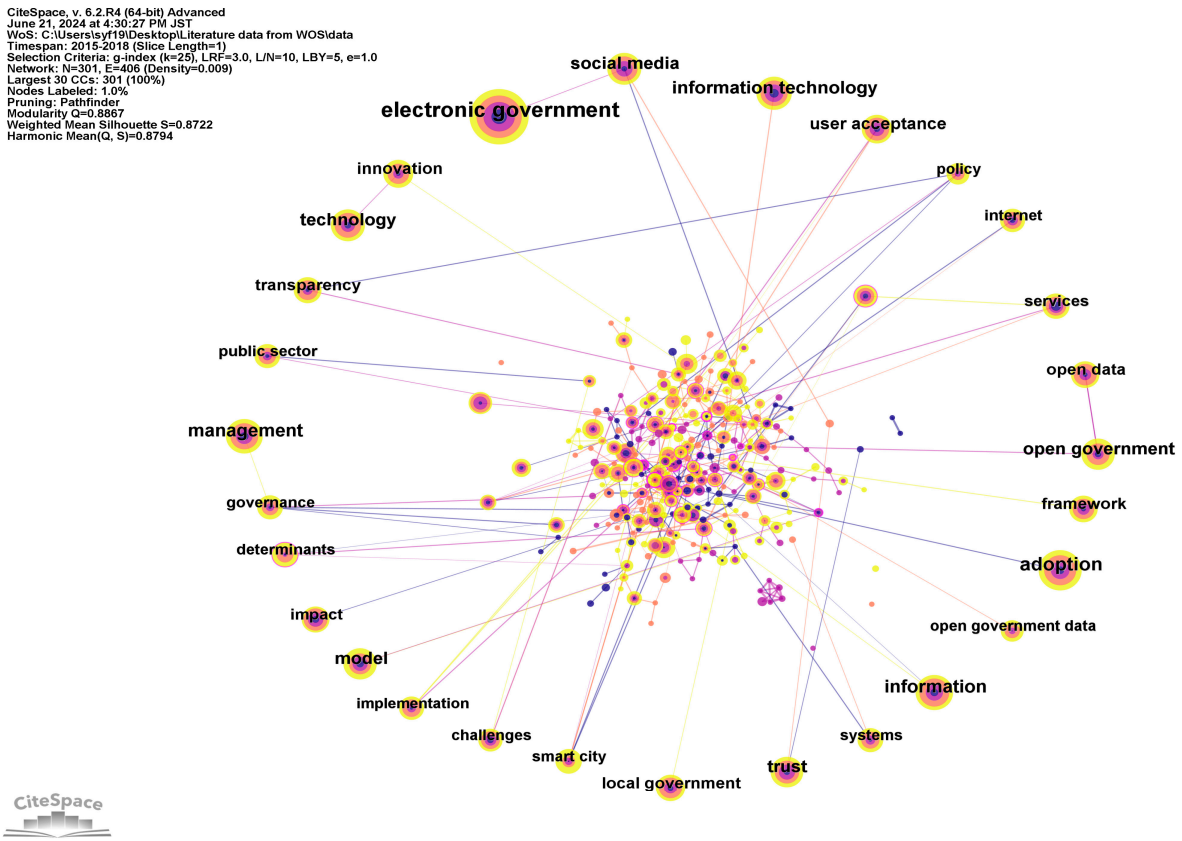

Figure 4. Keyword co-occurrence network during the development period (2015–2018).

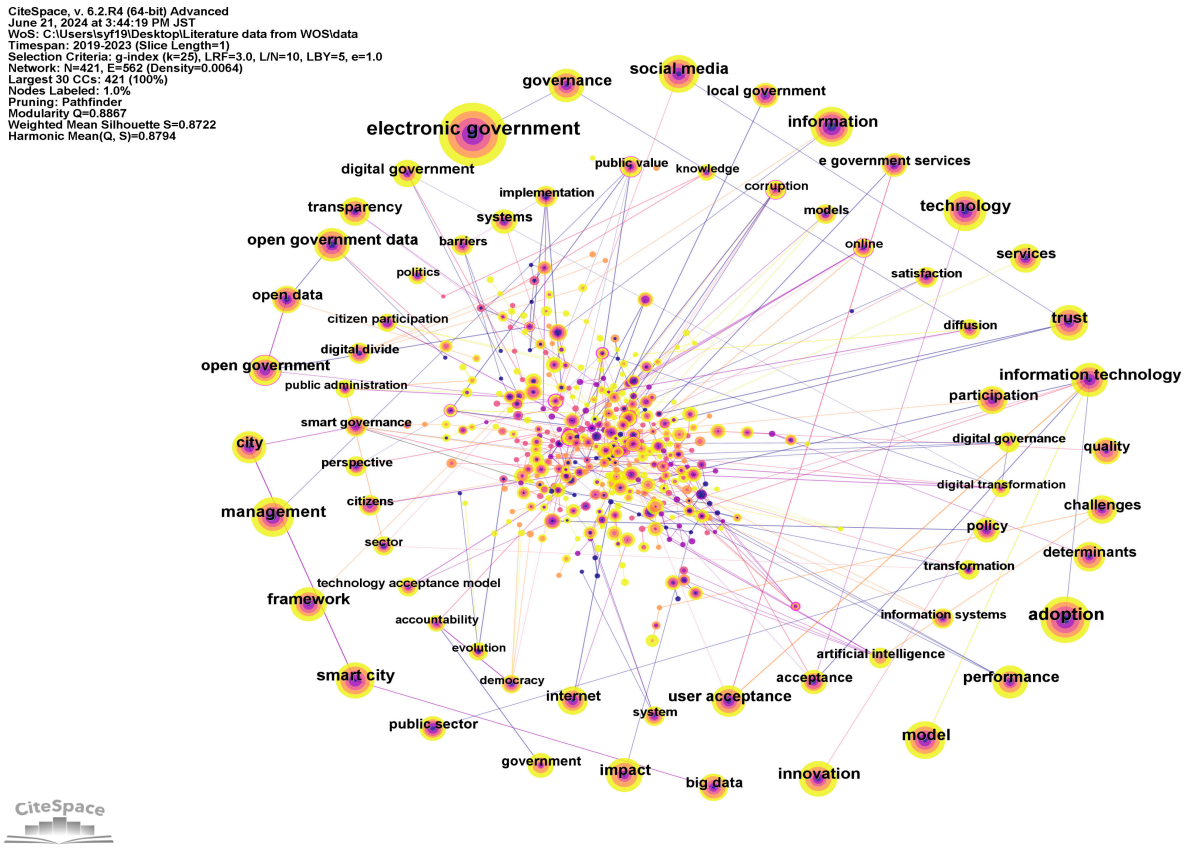

Figure 5. Keyword co-occurrence network during the growth period (2019–2023).

Moreover, this paper provides a detailed comparison of the top ten most frequently used keywords in each of the four periods, which is systematically presented in Table 3, thereby illuminating the shifts in research priorities over time.

Table 3. The comparison of the top 10 high-frequency keywords in each of the four periods.

Four Periods of E-Government Evolution	Ranking	Keywords	Count
The budding period (2000–2003)	1	electronic government	8
	2	technology	7
	3	information technology	6
	4	information	4
	5	digital government	3
	6	policy	3
	7	systems	3
	8	access	2
	9	electronic commerce	2
	10	government	2
The bottleneck period (2004–2014)	1	electronic government	248
	2	technology	128
	3	information technology	106
	4	information	102
	5	adoption	99
	6	model	93
	7	management	89
	8	internet	80
	9	trust	77
	10	services	64

Table 3. *Cont.*

Four Periods of E-Government Evolution	Ranking	Keywords	Count
The development period (2015–2018)	1	electronic government	250
	2	adoption	137
	3	information	106
	4	management	100
	5	technology	93
	6	information technology	91
	7	social media	87
	8	open government	84
	9	trust	84
	10	model	82
The growth period (2019–2023)	1	electronic government	442
	2	adoption	239
	3	technology	176
	4	management	172
	5	information	170
	6	model	159
	7	social media	158
	8	smart city	144
	9	innovation	140
	10	trust	140

Over the last two decades, E-government research has undergone significant evolution, marked by distinct phases, each characterized by unique thematic focuses and shifts. During the budding period (2000–2003), the research was foundational, concentrating on basic concepts such as "electronic government", "technology", and "information technology", reflecting initial efforts to integrate digital processes in government operations. Transitioning into the bottleneck period (2004–2014), the field deepened, evidenced by a dramatic increase in the diversity and frequency of keywords like "adoption", "trust", and "services", indicating a shift towards understanding user acceptance and the complexities of digital government services. In the development period (2015–2018), there was a notable shift towards engaging contemporary issues such as "social media" and "open government", suggesting a broader approach to inclusivity and transparency in governmental practices. Finally, the growth period (2019–2023) witnessed a surge in both the range and frequency of keywords. The focus notably shifted towards "smart city" and "innovation". These emerging keywords signify a trend towards integrating E-government into smart urban development and exploring innovative technologies and strategies. This reflects an interest in optimizing public services and enhancing urban management and sustainability alongside ongoing themes like technology adoption and trust. This period marks a deeper engagement with the role of E-government in urban innovation and development.

To observe the changing trend of these high-frequency keywords more intuitively, this paper plots the trend of keywords according to the frequency of these keywords in different periods, which is shown in Figure 6.

Figure 6 reveals a substantial escalation in the mention of the keyword E-government, climbing from eight instances in the early 21st century to 442 in recent times, underscoring its escalating significance in both scholarly and practical arenas. Correlating terms such as technology, information technology, and digital government, as well as policy, systems, and management, have consistently garnered increasing attention, highlighting the ongoing focus on the technical and managerial dimensions. Since 2004, the significant rise in terms like adoption and trust underscores a growing emphasis on the importance of user acceptance and public confidence in E-government frameworks.

Keywords	The count of high-frequency keywords in these different periods				Trend lines
	(2000-2003)	(2004-2014)	(2015-2018)	(2019-2023)	
electronic government	8	248	205	442	
technology	7	128	73	176	
information technology	6	106	80	134	
information	4	102	88	170	
digital government	3	21	20	83	
policy	3	31	37	69	
systems	3	64	43	67	
access	2	16	15	34	
electronic commerce	2	7	6	6	
government	2	35	21	68	
adoption	0	99	114	239	
model	0	93	71	159	
management	1	89	84	172	
internet	1	80	40	93	
trust	0	77	68	140	
services	0	64	47	90	
social media	0	34	74	158	
open government	0	40	71	105	
smart city	0	4	43	144	
innovation	0	34	56	140	

Figure 6. The development trend of high-frequency keywords in different periods.

Compared to the previous period, the frequency of most keywords decreased during 2015–2018, with only a few experiencing an increase, such as policy, acceptance, social media, open government, smart city, and innovation. Among them, adoption, social media, and open government have the highest frequency, symbolizing that government transparency and public participation are the key concerns during this period.

From 2019 to 2023, interest in most topics has increased, particularly in smart cities, which saw the fastest growth rate at about 235%, followed by innovation at 150%. This reflects an increasing interest in innovative approaches and the integration of E-government services. While less prominent, keywords like social media, adoption, and management also saw significant increases of 114%, 110%, and 105%, respectively, indicating sustained scholarly attention to these themes.

Overall, it is evident from the data presented in Figure 6 that there has been a general increase in scholarly attention across various themes within each topic during the 2019–2023 period. This trend also reflects reality. Namely, amid the COVID-19 pandemic, the scope of E-government research has expanded significantly and has received a high level of interest across a wide range of themes. This broad interest likely stems from an urgent need to adjust public services and governmental operations to meet the challenges introduced by the pandemic, emphasizing the crucial role of E-government solutions in modern governance.

4.3. The Evolution of Clusters in the Timeline

In this paper, cluster analysis is based on literature co-citation maps and utilizes the LLR algorithm for keyword clustering. In the keyword clustering results, the lowest Q value is 0.824, and the lowest S value is 0.853, both significantly exceeding the standard values. This indicates that the clustering results in this study are reasonable and reliable. Figures 6–9 each display the results of keyword clusters corresponding to four distinct developmental periods. These clusters highlight key research priorities and emerging trends. To provide a comprehensive picture of the changes and continuities in the academic discussion surrounding E-government, we further examined the dependencies between the different clusters based on the cluster analysis.

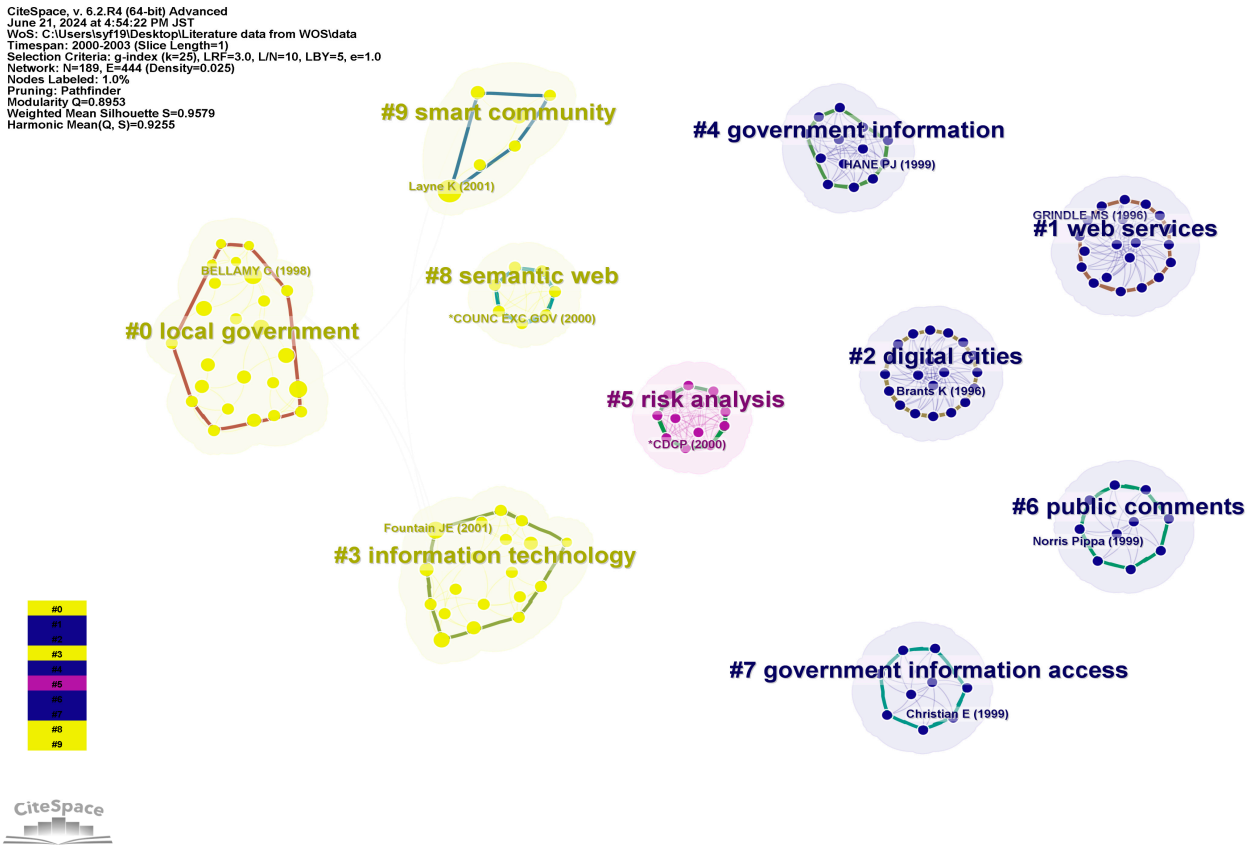

Figure 7. The cluster of keywords during the budding period (2000–2003).

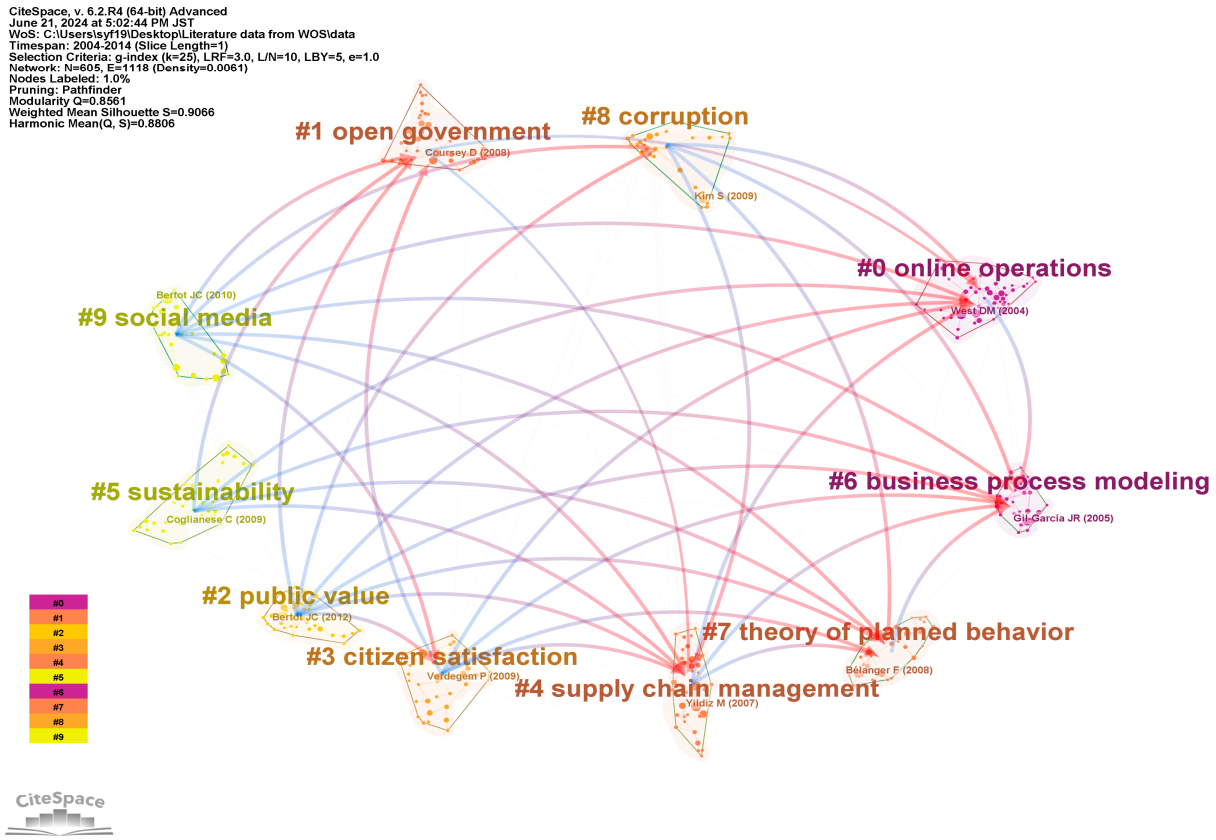

Figure 8. The cluster of keywords during the bottleneck period (2004–2014).

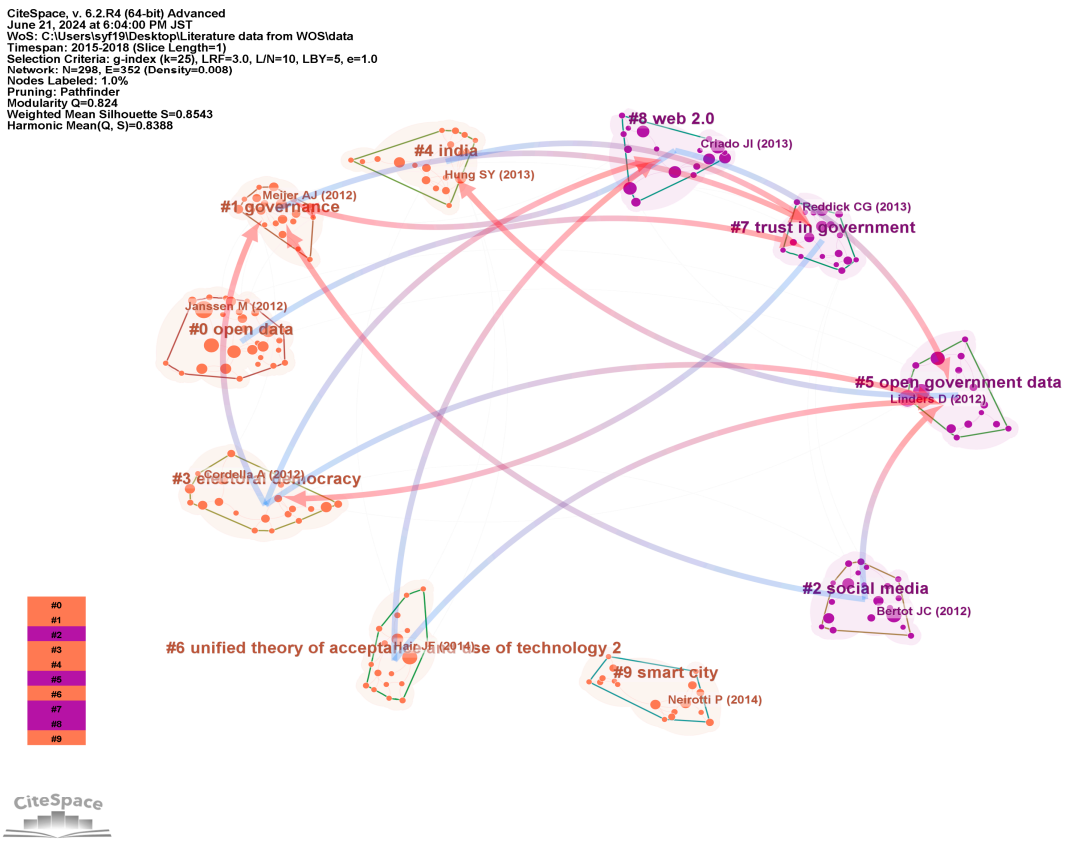

Figure 9. The cluster of keywords during the development period (2015–2018).

It is important to note that only the top 10 largest clusters in each period were selected to represent the main research topics of that time. This selection criterion was implemented to provide a focused and representative overview of the primary academic interests and topical explorations in each stage of E-government research development. The color of the clusters represents their respective years. The darker colors indicate older studies, while lighter colors signify more recent research. The arrows between the different clusters show the relationships between them. Specifically, the cluster pointed to by the arrow affects the cluster from which the arrow originates(Li and Li 2024; Qian et al. 2023).

Figure 7 illustrates that during the initial period (2000–2003), E-government research primarily focused on the digitalization of government functions and technical means, such as web services, public comments, and information technology. Among the ten largest keyword clusters, research on web services, digital cities, government information, public comments, and government information access began earliest, followed by risk analysis. Research on local governments, information technology, semantic networks, and smart communities emerged later. Notably, although research on local government started relatively late, it remains the largest cluster in this period, comprising 24 articles. The most frequently cited work in this cluster is a book of Bellamy and Taylor (1998), which emphasized the automation of tasks and functions as a source of public value creation. This idea became the basis for the current concept of E-government. During this period, we observed that the clusters were independent of each other and did not create dependencies. This is understandable, as this period was the beginning of E-government research, with more exploratory case studies and a lack of clear understanding of the definition of E-government (Yildiz 2007).

Figure 8 highlights the ten largest clusters during the bottleneck period. Early research focused on online operations and business process modeling, later shifting to open government, supply chain management, the theory of planned behavior, public value, citizen satisfaction, and corruption. Towards the end of this period, sustainable development and social media became key focal points. In comparison to the preceding period, the clusters observed in the bottleneck period are no longer independent of one another. Rather, they are in a state of mutual influence, which suggests further maturity in the field of E-government. Overall, the early research deepened the focus on technical methods and the digitization of government functions (e.g., online operations and business process modeling) from the previous phase. Building upon the findings of earlier research, the mid-term research during the bottleneck period has delved deeply into the application issues of E-government, encompassing such topics as E-government acceptance (e.g., citizen satisfaction, planned behavior theory), E-government value (e.g., public value), government transparency and corruption (e.g., open government, corruption), government functions (supply chain management), and so forth. The subsequent research agenda is organized around two key areas. Firstly, research interest focuses on the effect of open government (e.g., sustainability), which is based on the findings of research into technology, government functions, and acceptance. Secondly, the research on the effects of social media is based on studies of government transparency, government functions, acceptance, and technology.

Figure 9 reveals that during the development period, research continued to deepen the late-stage interests of the previous period, such as social media, government trust, open government data, and democratic elections. Additionally, researchers expanded their focus from the impact of technological methods on government transparency to their impact on other government functions, including open data, governance, and web 2.0. Moreover, the emergence of the Unified Theory of Acceptance and Use of Technology 2 (UTAUT2) highlights the ongoing attention to E-government acceptance studies. The prominence of India reflects an increased interest in the implementation of E-government in developing countries. It is notable that the smart city is an independent cluster at this period and has no connection with other clusters. This is understandable because smart city research itself is multidisciplinary in nature, rather than a single research area developed from the field of E-government (Viale Pereira et al. 2017). Moreover, smart city is an emerging cluster

at this period, with only 17 papers. Therefore, the knowledge between smart city and E-government is still in a fragmented state.

Building on the previous period's focus on technological applications and the ongoing concerns about government transparency and corruption, Figure 10 shows that early interest in the development period further explored these issues, such as open government data, transparency, e-participation, and corruption. Subsequently, research delved into the impact of technological methods on government functions, including smart governance and public sector innovation. Additionally, there was a thorough examination of sustainability issues (e.g., natural resources) and E-government acceptance (e.g., trust, UTAUT). The emergence of empirical analysis indicates a transformation in research methods as E-government initiatives become more widespread. Overall, this period maintained a continuous focus on the research topics of the previous era. Although the cluster on public sector innovation emerged as the latest research focus in this period, it quickly became the fifth largest in size. This suggests that in the next period, the impact of technological methods on government functions will remain a critical area of interest, requiring sustained attention. Interestingly, although the cluster of smart governance was affected by the COVID-19 pandemic, making it the largest cluster during this period (Radu and Popescul 2023; Sharifi et al. 2021). However, there is still a lack of knowledge linked to the field of E-government. This may limit the development of smart governance research.

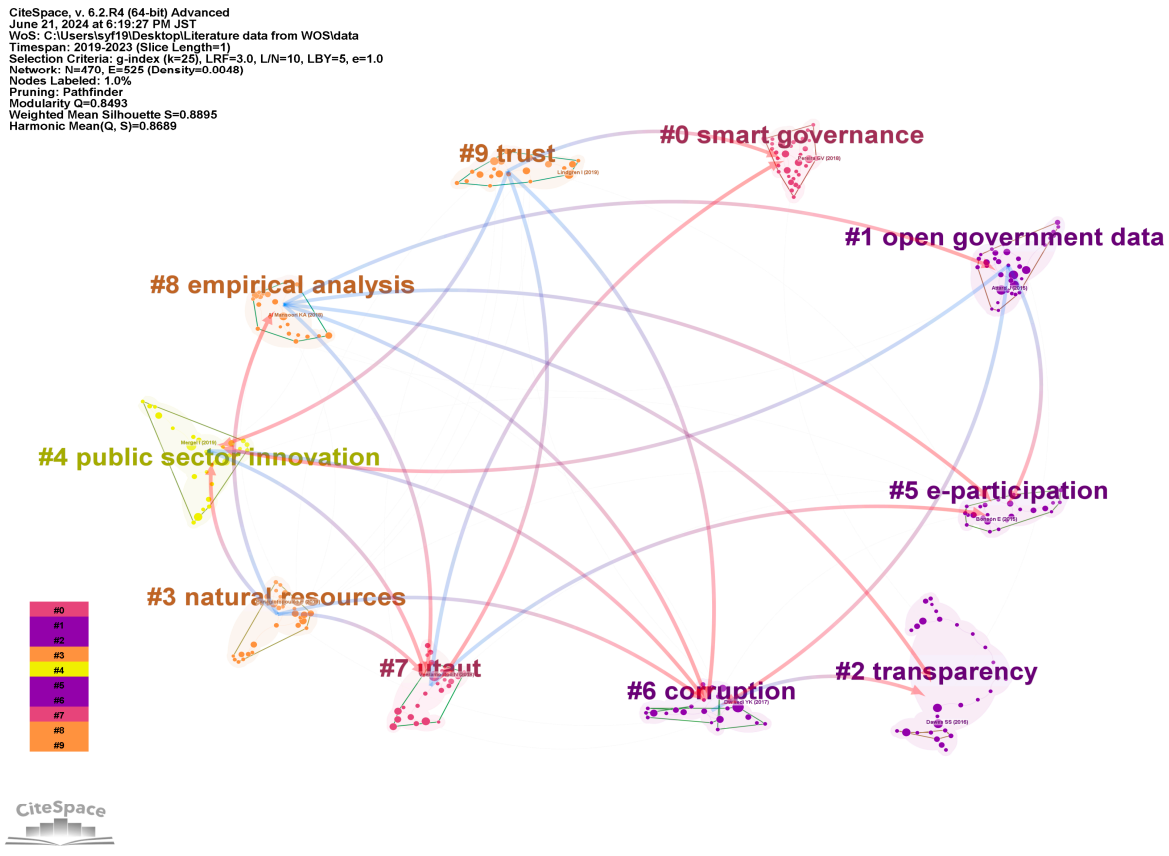

Figure 10. The cluster of keywords during the growth period (2019–2023).

4.4. The Citation Bursts of Different Categories on the Timeline

Due to the multidisciplinary character of research in the field of E-government, this paper uses citation burst analysis to provide a detailed list of the precise duration of disciplinary influence, which further enhances the understanding of the evolution of knowledge in the field of E-government. The results are shown in Figure 11.

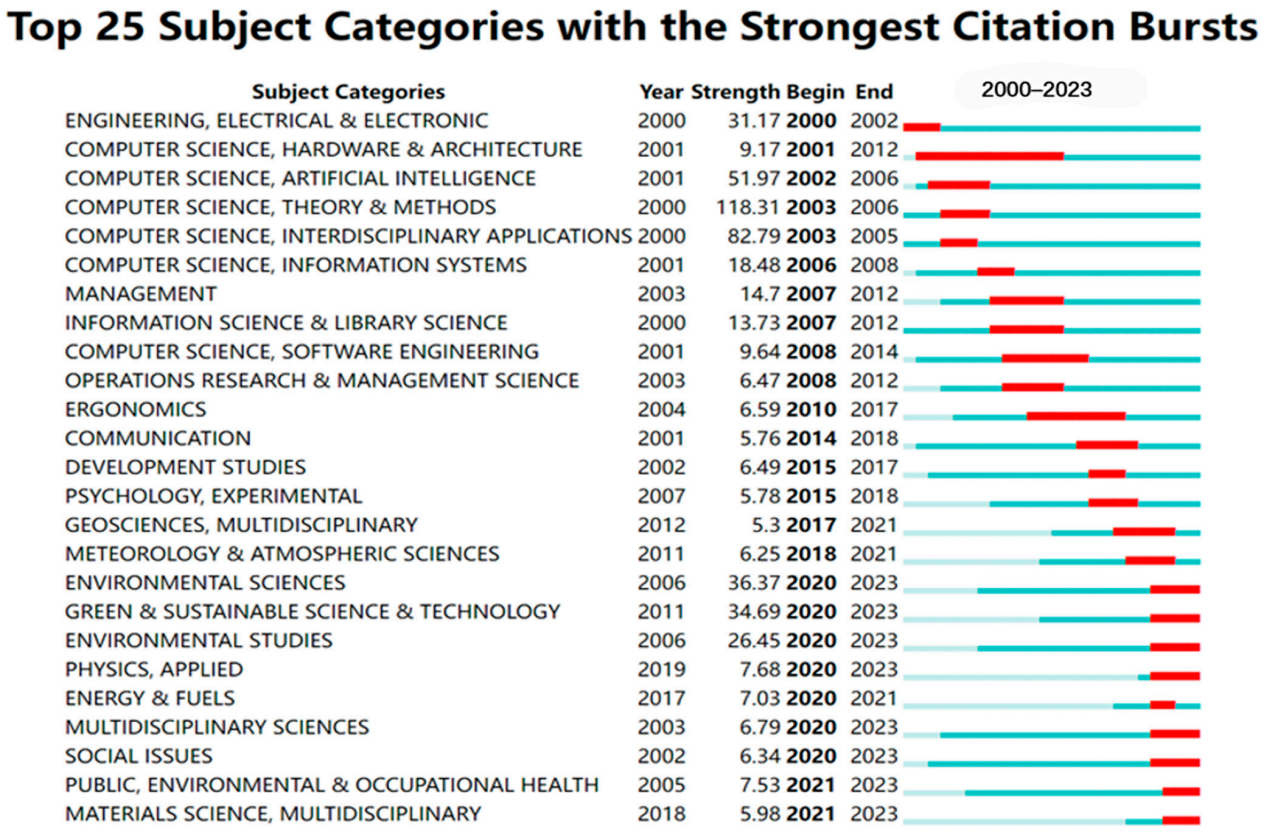

Figure 11. Top 25 subject categories with the strongest citation burst.

Among the various categories, COMPUTER SCIENCE, THEORY & METHODS had the highest burst intensity, and COMPUTER SCIENCE, HARDWARE & ARCHITECTURE had the longest duration. These results show that technology-related categories are central to the E-government field.

During the budding period (2000–2003), the citation bursts were all in technology-related categories. This shows that the starting point in the field of E-government is to begin with these technology-related categories. In the early stage of the bottleneck period (2004–2014), technology-related disciplines such as computer science and information systems remained the core of this period. Then, in the middle of the bottleneck period, some non-technology-related disciplines began to flourish, such as MANAGEMENT. In the later stage of the bottleneck period, more non-technology-related disciplines began to become the main force of research, such as OPERATIONS RESEARCH & MANAGEMENT. During the development phase (2015–2018), non-technical related categories such as COMMUNICATION, DEVELOPMENT STUDIES, PSYCHOLOGY, EXPERIMENTAL, and GEOSCIENCE, MULTIDISCIPLINARY became the central categories of this period.

By the development period (2019–2023), it is clear that multidisciplinary research has become mainstream. In addition, sustainability-related categories (such as ENVIRONMENTAL SCIENCES, GREEN & SUSTAINABLE SCIENCE & TECHNOLOGY, ENERGY & FUELS, and ENVIRONMENTAL STUDIES) and psychology (e.g., PUBLIC ENVIRONMENTAL & OCCUPATIONAL HEALTH) have also become the main research areas in the field of E-government. In particular, the categories related to sustainability, including ENVIRONMENTAL SCIENCES, GREEN & SUSTAINABLE, and ENVIRONMENTAL STUDIES, were the top three categories during this period, with strengths of 36.37, 34.69, and 26.45, respectively.

5. Discussions

5.1. E-Government Evolution over the Past 23 Years

It is well recognized that governments are vigorously pursuing digital transformation. This topic has garnered attention from academics, industry practitioners, government agencies, and consulting firms alike. Since the year 2000, a substantial body of research dedicated to E-government has been developed. Against this backdrop, the present study employs visual bibliometric analysis to explore the E-government literature from 2000 to 2023. This paper categorizes the evolution of E-government into four distinct phases: the budding period (2000–2003), the bottleneck period (2004–2014), the development period (2015–2018), and the growth period (2019–2023).

The first is the budding period, from 2000 to 2003. During this time, E-government research was just beginning (see Figure 1), with active disciplines predominantly related to technology (see Figure 11). Due to the short research duration and the highly singular nature of active disciplines, the research focus was limited (see Figure 2), concentrating on basic concepts and technological methods of E-government (see Table 3). It is noteworthy that since the field was in its infancy, knowledge clusters were relatively independent (see Figure 7) and did not evolve or undergo in-depth exploration. As mentioned by Rodríguez Bolívar et al. (2016), early studies mainly focused on case studies and outcome evaluations of E-government initiatives, despite some issues such as untested early theories and a lack of progress in existing theories. Despite some problems with research in this period, the primary contribution of this period was the emergence of research interest in the digitization of public services (Ramzy and Ibrahim 2022), laying the foundational knowledge for the evolution of the field in the subsequent period.

The second stage is the bottleneck period (2004–2014). This period is characterized by stable, albeit fluctuating, growth in publications (see Table 1). However, the complexity and diversity of research themes significantly increased during this time (see Figure 3). From the perspective of knowledge evolution, this period can be broadly divided into early, middle, and late stages.

In the early stage, researchers delved deeply into the nascent period's research interests, focusing on technological methods and E-government functions (see Figure 10). Technological disciplines continued to dominate (see Figure 11). During the middle stage, the research focus shifted towards the application aspects of E-government. For instance, Norris and Moon (2005) used data from two national surveys to conduct a longitudinal empirical study of the adoption of E-government by local governments in the United States, the complexity of websites, the perceived impact of E-government, and the barriers to E-government adoption and complexity. Thus, non-technological disciplines such as management began to gain prominence, and the frequency of non-technological keywords like "acceptance" and "model" increased significantly in this stage (see Figure 6). Attention to government corruption and transparency also grew, as highlighted by Yildiz (2007), who noted that E-government reforms could challenge issues of corruption and transparency. Consequently, keywords such as "trust" and "open government" saw a significant rise in frequency (see Figure 6). In the late stage, the focus shifted towards the effects of E-government adoption and transparency concerns. Research began to emphasize the impact of technological methods, such as social media, on government transparency and corruption and the outcomes of E-government, including sustainable development (see Figure 8).

During the development period (2015–2018), although the annual publication growth rate exceeded that of the bottleneck period (2004–2014), the research focus was narrower compared to the previous period (see Figure 4). This was due to more concentrated research interests and a relatively uniform disciplinary background, with non-technological disciplines becoming predominant (see Figure 11). Overall, this period saw a more in-depth exploration of government transparency, corruption issues, and the adoption of E-government (see Figure 9). How technology transforms government services became a new topic of interest. The keyword trend chart in Figure 6 also shows that during this

period, only keywords such as social media, open government, smart cities, and innovation increased in frequency, while the frequency of keywords related to other topics declined to varying degrees. Notably, Jiang et al. (2022) attributed the lack of breakthroughs during this period to the inadequacy of innovative technologies and methods. As seen in Figure 11, technology-related disciplines were not active during this period, and our research findings provide empirical support for this viewpoint.

The growth period (2019–2023) marks another phase of exponential growth in E-government research. During this time, the total number of keywords increased to 421. Innovation and smart cities became significant focal points, while attention to previously important research areas also saw substantial growth (see Figure 6). This study posits that the research boom during this period was fueled by opportunities arising from technological breakthroughs and the rapid improvement of E-government infrastructure.

From a macro perspective, technology-related disciplines regained vitality in the E-government field between 2019 and 2023, including PHYSICS, APPLIED, and MATERIALS SCIENCE, MULTIDISCIPLINARY. Practically, the European Union's publication of the "Ethics Guidelines for Trustworthy AI" in April 2019 set a benchmark for AI governance (EU 2019). In June of the same year, Google AI launched the BERT model, significantly advancing natural language processing (NLP) tasks and garnering widespread attention in the AI community (Devlin et al. 2019). BERT's outstanding performance at the prestigious Association for Computational Linguistics (ACL) conference likely sparked greater public sector interest in AI applications, supporting our viewpoint to some extent. Additionally, we observed that sustainability-related disciplines (e.g., environmental sciences) and psychology-related disciplines became new mainstream areas during this period. Notably, sustainability-related disciplines ranked among the top three in citation burst intensity, contributing to the emergence of new topics and the deepening of existing themes, thus advancing research in the E-government field.

Moreover, as shown in Figure 10, public sector innovation, although a nascent topic, has already become the fifth largest cluster, indicating researchers' strong interest in this area.

5.2. The Role of COVID-19 Pandemic in the Evolution of Research in the Field of E-Government

Based on the preceding discussion, the research fervor that began in 2019 can primarily be attributed to technological breakthroughs and supportive policies. However, the pandemic in 2020 compelled governments to undergo rapid digital transformations to address the crisis's challenges and forced citizens to increase their use of E-government services (Gkeredakis et al. 2021). During this period, the efficacy of many emerging technologies in governance was validated, and various innovative initiatives were launched, thereby accelerating the application and broad implementation of new technologies in governance. Consequently, these developments have sustained and accelerated the explosive growth in E-government research.

For instance, during the pandemic, the South Korean government shared data such as mask inventories with the public. Technologically savvy individuals and groups utilized this information, along with open APIs provided by the government, to develop various mobile applications to manage the crisis (Kim 2020). Similarly, artificial intelligence, big data, and other emerging technologies were used during this pandemic for purposes such as diagnosing conditions, tracking or predicting outbreaks, and providing counseling (Pham et al. 2020). Furthermore, a study of the Austrian public sector noted that during the pandemic, government employees' digital skills were strengthened, government resources were redirected towards digitally enhanced services, and the methods of communication among government departments changed (Moser-Plautz and Schmidthuber 2023). In fact, these innovations have significantly advanced the popularization and development of E-government research.

Additionally, the crisis brought more disciplines into E-government research, such as psychology and sustainability-related fields. For example, Mat Dawi et al. (2021) revealed

through an online survey of 404 Malaysian residents that perceptions of E-government information and services, as well as perceptions of social media, were significant predictors of preventive behavior attitudes. Their findings highlighted the importance of digital platforms in improving attitudes towards preventive behaviors and thus curbing the spread of infectious diseases. Furthermore, Kuzior et al. (2022) emphasized that smart cities demonstrated greater resilience to the COVID-19 pandemic, with lower citizen mortality rates. Strielkowski et al. (2022) pointed out that the COVID-19 pandemic provided an excellent opportunity for governments to deploy more intelligent and sustainable cities.

Moreover, comparing the clustering results of the development period (2015–2018) and the growth period (2019–2023) in this paper, it was found that the majority of themes during the growth period were in-depth continuations of earlier themes, with few new topics emerging (see Figures 8 and 9). This observation aligns with the normal evolutionary patterns observed between periods. Therefore, this paper argues that while this pandemic was not the root cause of the research boom that began in 2019, it acted as a catalyst that greatly contributed to and sustained the development trend of E-government research.

5.3. Future Research Priorities

Despite the continuous attention and research on E-government in recent years, the research potential in this field remains substantial. Although there is a considerable body of existing literature, further research is still necessary.

Figure 6 shows a significant rise in research focus on various E-government themes during the 2019–2023 period. Notably, "innovation" and "smart cities" emerged as two of the top ten high-frequency keywords in this period, indicating that research topics related to these keywords are likely to become highly prioritized in the future.

As highlighted in a previous study by Zimmerling and Chen (2021), the COVID-19 pandemic period was characterized by both heightened social and economic pressures and notable technological opportunities, which are recognized as key drivers of innovation. A considerable amount of innovation has indeed occurred during this period. For example, there have been notable changes in the communication methods among government departments (Moser-Plautz and Schmidthuber 2023) and between governments and the public (Zimmerling and Chen 2021). Additionally, there has been increased collaboration with citizens through the use of open data and the incorporation of diverse emerging technologies in the delivery of public services (Moon and Cho 2022).

While these technology-driven innovations have shown promising results in advancing digital government transformation and addressing pandemic-related challenges, some researchers have expressed concerns. Future efforts must reassess and reinforce these initiatives to ensure they maintain high levels of efficiency and effectiveness in normal circumstances (Gkeredakis et al. 2021; Zimmerling and Chen 2021). Secondly, future research should also focus on the impact of rapid digital transformation on groups with low digital skills (e.g., individuals with low educational attainment and the elderly) to ensure they can adequately use government services. Thirdly, there is a need to investigate whether the current rapid digital transformation might exacerbate government transparency and corruption issues and, if so, how these issues can be addressed.

The clustering results for the growth period in this paper also support the notion that research on smart cities will emerge as a prominent focus in the future (see Figure 10). Due to the excellent performance of a range of emerging technologies in combating the pandemic, several researchers argue that this highlights the potential of smart cities to respond to crises, thus promoting the process of smart city building (Radu and Popescul 2023; Sharifi et al. 2021). However, it also means that a more refined institutional mechanism or legal framework will need to be explored in the future. Additionally, the current research on smart cities and their knowledge linkages with E-government remain limited, which may constrain the development of smart city research. Future studies could attempt to integrate the existing knowledge of smart cities and E-government to foster research progress. For

example, investigating how smart cities can enhance government transparency would be a valuable area of exploration.

Finally, given the multidisciplinary nature of E-government research, future studies could aim to integrate knowledge from different disciplines. For example, existing models for E-government acceptance, such as the Technology Acceptance Model (TAM), Unified Theory of Acceptance and Use of Technology (UTAUT), and UTAUT2, predominantly originate from the information systems (IS) field. Future research could incorporate elements from psychology into these E-government acceptance models to enhance their robustness and applicability.

6. Conclusions and Research Limitations

This study employs a visual bibliometric method to analyze 4536 publications from the SSCI and SCIE databases, spanning the period from 2000 to 2023. The research focuses on the development trajectory of the E-government field, dividing it into four distinct periods: the nascent period (2000–2003), the bottleneck period (2004–2014), the development period (2015–2018), and the growth period (2019–2023). By constructing co-occurrence maps and clustered knowledge graphs of keywords for each period, as well as citation burst charts of disciplines, this study explores the characteristics and transitions of research across these periods.

The findings indicate that the research surge in the E-government field after 2019 is primarily attributed to opportunities from technological innovation and the improvement of infrastructure. Additionally, the COVID-19 pandemic not only accelerated the rapid digital transformation of governments but also drew the attention of researchers from various disciplines to the field of E-government, acting as a catalyst for its research development. The study predicts that innovation and smart cities are likely to be the most prominent themes in the future and provides some suggestions for their future development.

Notably, the research surge post-2019 has actually increased attention to various research themes. To our knowledge, this study is the first to include post-2019 E-government research in visual bibliometric analysis and to reveal the knowledge transformation journey of E-government across different periods.

This study contributes both practical and academic insights. First, this paper is the first to include post-2019 research on E-government in a visualized bibliometric analysis, offering an in-depth examination of the dynamic shifts in research themes and focuses over various periods. By creating detailed knowledge maps, this paper furnishes a fresh, comprehensive view of the scientific landscape in the field of E-government, enabling researchers, policymakers, and stakeholders to grasp the knowledge structure and evolutionary trends of the field more effectively and conveniently. Additionally, this paper explores current research hotspots and development trends, delivering key insights into future directions for E-government, thereby laying a foundation for subsequent academic research and policy formulation. Moreover, it discusses the intrinsic reasons behind the surge in interest in 2019 and the influence of the COVID-19 pandemic on expediting digital government initiatives, offering evidence-based guidance to policymakers.

Although this paper provides comprehensive insights into the evolution of E-government research, it has some limitations. Firstly, this study relies on the SSCI and SCIE databases. While reputable, these databases may not encompass all E-government publications, potentially overlooking significant literature from other sources or grey literature that could offer additional perspectives. Secondly, dividing E-government research into four distinct periods, while helpful, may oversimplify transitions between stages, failing to fully consider overlapping development or continuous progress in E-government research. Furthermore, although broad trends and emerging themes such as innovation and smart cities are identified, the paper may not fully account for the diversity and depth of individual studies within each period. This could lead to a generalized understanding that does not adequately reflect nuanced changes and specific advancements. Lastly, while the search terms used were aligned with the concept of E-government, some retrieved liter-

ature may not be directly related. Keywords like "digital era governance" OR "digital-era governance" might retrieve literature about private organizations rather than public ones. This highlights the challenge of ensuring specificity and relevance in search terms.

Given these limitations, future research should integrate a broader data foundation to comprehensively collect global E-government research outcomes. Researchers should also explore more detailed periodization methods that account for the complexity and continuity of E-government development. Advanced statistical techniques or flexible developmental stage models may better capture overlaps and unique contributions. Moreover, while broad trends are valuable, future research should delve into specific themes like the impact of smart cities and E-government innovation. Detailed case studies, comparative analyses, and empirical research can further elucidate these themes. Finally, advanced bibliometric tools and techniques, such as text mining and machine learning algorithms, should be considered to enhance the accuracy and relevance of literature retrieval.

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